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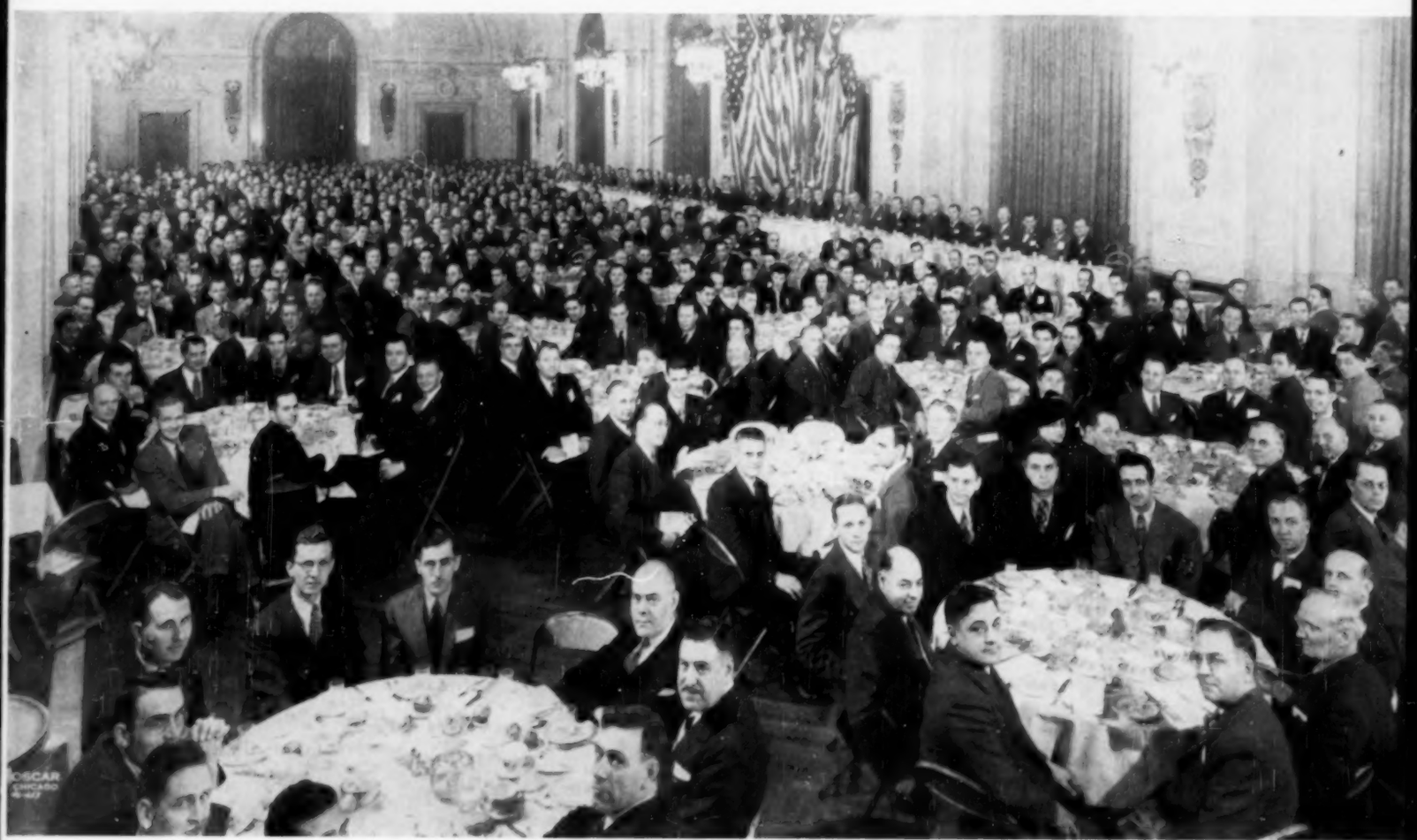

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Table of Contents

	Page
Notice to Subscribers	3
Midwest Quality Control Conference	4
Report of Midwest Quality Control Conference Quality Control—A Management Tool, M. Herbert Eisenhart	5
Industrial Statistics Looks at the Future, Paul Peach	7
A Complete Quality Control Program, Joseph Manuele	9
Foundry Applications of Quality Control, William M. Armstrong	12
The Future of Quality Control, George D. Edwards	16
Limits for Control Charts—Second Article, Preston C. Hammer	20
Reports of the Rochester Clinic	23
Society Reports	27
Michigan Quality Control Forum	30
Rochester Institute Course	30
University of Illinois Course	30
American Society News	31

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General Information

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COST OF BACK ISSUES

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INDUSTRIAL QUALITY CONTROL
was founded in 1944 by the
SOCIETY OF
QUALITY CONTROL ENGINEERS
BUFFALO
in cooperation with
THE UNIVERSITY OF BUFFALO

MIDWEST QUALITY CONTROL CONFERENCE

The demand for publication of the proceedings of the Midwest Conference from those who attended, as well as from those who did not attend, has been so persistent that the Conference Management has made arrangements to have the complete proceedings published in INDUSTRIAL QUALITY CONTROL, beginning with this issue. The first installment, including most of the papers presented on the first day of the Conference, appears in pages 5 to 19. The intention is to have the Conference reports put into the hands of all those attending the Conference who are members of the American Society for Quality Control. Simultaneously the reports become available to all other members of the Society and to the residual subscribers to the magazine.

The editorial preparation of these reports is under the direction of Professor Mason E. Wescott, Northwestern University, assisted by C. W. Richards, J. L. Shafer, H. G. Thompson, Lloyd Knowler, I. Burr, J. Henry, H. Becker, H. R. Kellogg, Lt. Col. Ed. Don, Miss Bonnie Small. The plan of presentation of the Clinic reports will be given in detail in subsequent issues.

With this issue the magazine is being increased from 20 pages to 32 pages. The Conference Reports are therefore an addition to the regular content of the magazine. This same policy will be followed in succeeding issues.

COVER PICTURE

This picture was taken at the Tuesday luncheon of the Midwest Quality Control Conference in the Ball Room of the La Salle Hotel. The speakers' table and a large part of the 600 guests are shown. The original of this picture is 12"x20".

Copies are available from the Midwest Quality Control Conference, Post Office Box 1097, Chicago 90, Illinois, at a price of $2.00.

REPORT OF MIDWEST Quality Control Conference

Quality Control---A Management Tool

M. HERBERT EISENHART

PRESIDENT, BAUSCH & LOMB OPTICAL COMPANY

[**Presented at Luncheon, March 5**]

I have been asked to talk to you briefly on the subject of quality control, a management tool. I shall tell you why it seems to me this tool is so important. It is the most recent addition to a large collection of tools demonstrating the ingenuity of American management in the interest of maintaining our world supremacy as an industrial nation.

The history of America has been one of continual evolution. Today we find American management concerning itself not only with a continuance of inventive genius and the study of materials and processes, but also in more recent years taking advantage of new techniques that have become increasingly important. As businesses have become larger and more competitive, the principles of scientific management which were first introduced soon after the turn of the century have led to increased efficiency. The development of engineering and research is an important contributing element. No modern business organization can be secure without full recognition of the importance of its research facilities. Great and far-reaching progress has been made with the principles of cost accounting, for no business can long continue to exist without a current, comprehensive, and accurate idea of the cost of its operations. The field of industrial relations with its many ramifications in the interest of good management-employee relations needs no justification. As a business grows in size, the problem of the control of inventory is another tool with which management must concern itself. Finally, I should like to mention the ingenuity involved in the effective budgetary controls which must play such an important part in the successful operations of any business. In these days of high taxes, price controls, and all kinds of government regulations, a predetermined financial program against which the daily activities can be measured furnishes the only possible means of survival. I speak of this budgetary control with a deep personal conviction that every industrial manager must use and make it increasingly effective and accurate if he is to succeed in his job.

The American industrial organization is a very intricate and delicately balanced structure and one which can only be successful if management takes full advantage of the facilities available. During the early stages of any manufacturing enterprise when the number of people involved is small and the time is available for the originator of the enterprise fully to supervise production, the adherence to quality is one which can be relatively easily controlled. On the other hand when the organization grows and the processes of manufacture are spread out into many machine operations and departmental responsibilities, the element of quality becomes increasingly more complex. It is because of these conditions that a system of quality control becomes so vital and so important a tool in the hands of management.

Why are we concerned about quality? It is perfectly obvious that as competition becomes keener, the necessity of winning a market and convincing the public of the value of a product will constantly re-emphasize the importance of making a finished article which will justify acceptance by the public. This same competitive system as it becomes more intense puts the purchaser in a critical mood as regards both price and quality. It scarcely seems necessary for any one to justify the importance of quality control. The problem which lies ahead of us is how this can be most effectively handled in our manufacturing program so that the final product will be in accordance with the ideas and ideals of top management.

The evolution of our intricate manufacturing techniques makes it evident that quality now becomes of increasing importance. The viewpoint of top management must necessarily and thoroughly permeate the entire organization, and this can take place only when the importance of quality is thoroughly appreciated. It has always seemed to me that the maintenance of quality is quite definitely a matter of habit. I am sure the greatest detrimental factor to the maintenance of a reputation for quality on the part of any business is a disinterested attitude on the part of top management. This is bound to be reflected through the attitude of superintendents, foremen, supervisors, and even to the machine operators. In order to maintain

proper quality standards, the entire organization must be definitely and constantly reminded of the habit of accuracy and thoroughness. Unless this is carried out most effectively throughout the entire organization, there is bound to be relaxation of standards here or there which will ultimately affect the finished product.

Of course, quality control in its basic consideration presupposes an attitude of management definitely interested in the quality of product produced. Some manufacturing establishments can carry on production programs by depending upon the individual workmen to do a good job, and may thus have available for public use products of quite a satisfactory quality. This is a condition likely to obtain with the inception of a new business — somebody determines that there is a field for a product and the manufacture of this product is started in a small, easily controlled manner. When the business grows, however, and the number of people involved becomes greater, any management concerned with the maintenance of quality standards must find ways and means to safeguard this important concept. It is at this stage in the evolution of the business that quality consciousness on the part of management must play a very important role. It is to meet this situation that some techniques for the control of quality must be given important consideration. With the changing personnel in any factory organization, the quality concept must be constantly emphasized in order to maintain the predetermined specifications of the finished product.

Let us consider then the quality of the finished product as it leaves the plant. Here I believe the responsibility for inspection is a function which should be headed up, quite independently of the manufacturing procedures, directly to top management. This means that in the initial engineering department where the product is conceived there must be a thorough understanding and a practical interpretation of just what the quality of the finished product is to be. Now there are many factors which enter into the decision on these questions, not least of which is the quality of the competitive articles on the market. In any complicated article which is made up of the assembly of numerous sub-assemblies that in turn involve many mechanical parts, it is quite obvious that what might be considered an absolutely perfect article may be entirely too costly to produce. In other words, I believe all manufacturing establishments must be constantly concerned with the general level of competitive articles. In our own case we constantly maintain a very elaborate system of checks on the product available in the field, and the program of the company calls for a product at all times of a higher quality than any other on the market. Of course, these standards of inspection for final product are never a definite and frozen standard, for as new machines are developed and new processes perfected, costs are reduced and often the practical, effective quality is materially increased.

Standards of quality interpreted by the inspection control department are constantly under study in the light of these changed conditions. There are constantly forces at work which would have, on the other hand, a tendency to lower these final quality standards — from one side the drive of the sales department to meet competitive prices and from the other the pressure of the manufacturing organization to sacrifice quality in the interest of cost. And then there is always that marginal case where because something has been made and the money has been spent and the final product is not absolutely up to standard someone says, "Do not the circumstances justify letting this lot go by?" To safeguard against digressions from the quality concept it is necessary that the final functioning of the product as well as its appearance be directly under the control of top management. I recognize that there is a psychological danger in having a separate final inspection department, since those responsible for part manufacture may quite often unintentionally feel that chances can be taken, because defects, if bad, will ultimately be caught by the final inspector. With this thought in mind we in our own plant do not subject all product to the final inspection procedure I have just described. Where the flow of product is constant from day to day, we determine on a spot checking procedure and from these figures exercise the necessary judgment as regards the individual department inspection. In the larger and more intricately involved instruments we do have a 100% final check.

So far I have been considering the control of the quality of the final product as it leaves the plant, and I am sure there can be no question as to the importance of this control resting squarely on top management. The successful functioning, on the other hand, of such a department will be dependent as regards its size and degree of performance upon the quality of workmanship on all part manufacture and sub-assembly. It is the ambition in our plant to make this latter procedure so increasingly effective that that group responsible for final inspection will function principally as a spot checker, thereby from day to day tending to improve the performance within the individual factory departments. It is obvious then that if the engineering department assumes the responsibility for the standards of final inspection, this same engineering department must be a party to the individual part and sub-assembly inspection standards. In the complicated manufacture of an optical instrument, for example, where tolerances of mechanical as well as optical parts are involved, very good judgment must be used in the interpretation of all plus and minus limits. It is in this category of control of quality that the new techniques are particularly applicable. The interpretation of these standards for an individual mechanical part as it moves through the various machine operations calls for a systematic recording of inspection results at all vital points. These routine inspections of individual parts play an important role in the quality of the final product. The manufacturing superintendent in our plant has under his direction the inspection of all parts manufactured under his responsibility. It seems to us that this is a correct alignment of authority and responsibility, since involved in this inspection procedure is the corresponding control of costs which lead into the final operations of the business.

With a thoroughly coordinated manufacturing organization and with the responsibility for quality of the individual part resting with the superintendent, top management is kept constantly in touch with the quality of the product. If the final inspection control department is functioning properly in the organization, the records obtained at this point can and should be used most effectively by the manufacturing division to minimize the rejections at the final control point.

In conclusion let me re-emphasize the importance of the psychology of an entire organization if the ideals of top management are to be attained. The opportunities which lie ahead for American industry are unlimited in a world eager for the products of our manufacture. If we not only maintain our standards of the past but constantly seek to improve the quality of our product in the light of improved processes, we can retain our home markets and gain much of the world markets. The American system of free enterprise has been built on initiative and ingenuity and there is no nobler purpose to which we can aim than to maintain into the future the pre-eminent and successful record which American industry has demonstrated in a hundred and fifty years of growth, and more particularly in the phenomenal record established in these last five war years. Our job now is to apply the same initiative and drive to the making of peacetime products, and to this end I commend quality control as a management tool with unlimited possibilities.

Industrial Statistics Looks at the Future

PAUL PEACH

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[**Presented at Morning Session, March 5**]

Almost exactly fifty years ago, Frederick Taylor presented to the American Society of Mechanical Engineers the paper that ushered in the age of scientific management. Today there are still people to whom scientific management means time study and nothing more. There are also those to whom industrial statistics means control charts and inspection tables, nothing more. Actually, industrial statistics is the logical culmination of the scientific approach to management. It permits the application to machines and processes of the same quantitative analysis which time and motion study applies to hand operations. As trained people are developed, and as industry acquires the habit of working from the statistical angle, the engineering statistician and statistically trained executive must eventually become more and more important to our industrial organization.

It takes no statistics and no prophetic gifts to recognize four major trends in industry which, if they continue, must profoundly affect our economic life. They are

1. Decentralization of industry
2. Increased mechanization
3. Specialization of factories
4. Standardization of product

The decentralization of industry was not predicted by the economists of fifty years ago. The assumption has been that bigger factories are better factories — that the economic drive for cheaper production must always force increased centralization. Most persons have by now learned the lesson of the dinosaurs — that mobility, adaptability, and quickness of response are important, and size by itself is nothing. Most managers know now that a desk executive in New York cannot successfully manage a business in Atlanta or Minneapolis. On the basis of efficiency alone, much progress has been made toward the independent unit system. Like the amoeba, management must look for a level of maximum biological efficiency and keep plants at that level, breaking them up when they become too big.

It is natural to suppose that decentralization must work against efficient production. This is not necessarily the case. Consider the second point: Increased mechanization. The factory of the future will be relatively small in terms of people employed and perhaps floor space, but it will have a large production and will be efficient, not perhaps in comparison with Utopian ideal, but certainly in comparison with the alternatives among which a choice is available.

It is at this point in thinking of the future that quality control enters with a bang. How far can mechanization be carried? What impediments exist right now to g r e a t e r mechanization? One of the most important barriers is non-uniform material. Two consecutive heats of steel from the same mill do not have quite the same characteristics. Two supposedly similar screw machines have hidden differences which show up in the product. Textile yarns are uneven and break at the weak places. Everywhere in industry non-uniformity appears and wherever non-uniformity exists, there must be a human hand to adjust and repair. Wherever uniformity and consistency can be introduced, mechanization becomes possible. Now the study of product variability is the peculiar province of statistical quality control. It is the job of the quality control statistician to determine just how far it is possible to go in attaining product uniformity. With this information, the design engineer should be able to extend the process of mechanization. The success of such extensions depends upon feeding

to automatic machines a steady stream of uniform product. This is what the quality man means when he talks about "statistical control", — a steady stream of uniform product. Mechanization can go to the extent, and only to the extent, that feeder lines approach a state of statistical quality control.

Really intensive mechanization will necessarily bring vast social changes. Many people fear extensive unemployment as one result. Unemployment undoubtedly will persist, but it will not be due to mechanization of factories. In the future the total demand for labor may actually increase, but not many people will work in factories. The displaced people will be absorbed largely by service occupations — local shops, neighborhood service stations of various kinds, and so on.

Statistical quality control may influence evolution along this line in still another way. It may turn out that certain operations, even with the best possible statistical control, cannot be mechanized. In some cases the manufacturer will have a choice between using a hand assembly line in his factory, or selling the pieces for assembly by the consumer or service man. It is right now possible to buy women's dresses "knocked down" —all the pieces cut to size, some seams ready sewed, capable of being assembled by the customer or neighborhood dressmaker. In a very real sense such a practice increases employment: it provides work for the local entrepreneur, and makes it possible for consumers with the necessary ability to use productively time which would otherwise be wasted. The statistical engineer has two jobs here: first, to determine which operations should be done in the factory and which outside, and second, to design parts and sub-assemblies so that final assembly will require a minimum of skill and equipment.

It goes without saying that when giant factories divide, the daughter plants will do specialized jobs. It will then be possible to scatter factories widely, have each one make its part or sub-assembly, and ship the product either to assembly stations or direct to the consumer. There will be a delicate quality control job here, to manufacture parts in a hundred different factories and have them fit together at the end with no tool needed but a screwdriver. There will also be a delicate management question: should competitors' parts be interchangeable? Industry should adopt a policy of universal interchangeability, as machine and tool design problems would be much simplified, to say nothing of promoting the public convenience. Finally, industrial statistics will enter in estimating the demand for a product, and in arriving at the size and type of installation necessary to produce it.

The last of the four points has to do with standardization of product. Fully automatic machinery is expensive. Once installed, it is difficult to convert. There are two distinct problems: standardization by type, and standardization by size. With standardization by type statistics has little concern: but standardization by size is a statistical problem, and in two respects. In the first place, estimation of the market for each size is needed (and, of course, type too) in order to get economical production schedules. In the second place, each size will need to be statistically defined (something analogous to our drawing tolerances) with reference to the final destination of the piece and the method of assembly (factory, neighborhood shop, or home).

So much for that part of the future which should be obvious to all. Decentralization is not itself a statistical problem; but the problems raised by decentralization have important statistical aspects. There are a good many other problems, less obvious, which raise statistical questions. Industrial statistics looks at the future and detects a field of battle and not a bed of roses. Whatever the theories may be, the conviction is inescapable that, though the present may foreshadow the future, the future itself will be as different from today as the man is from the boy.

The manufacturer who breaks up his big factory into a number of small scattered units will enjoy a degree of security from labor unrest which no giant plant can ever have. Heretofore individual manufacturers have taken comfort from the fact that they had good labor relations in their plants, and so had nothing to fear. It must be obvious now that no such argument has any validity for big factories in highly industrialized areas. A mere handful of irresponsible men or a power-greedy leader can today paralyze any of the great cities. To escape from these dangers, if for no other reason, industries must leave the cities.

In the management of these small plants, statistics will play a great part. It is hardly to be expected that there will ever be enough men with native executive ability to run all these factories. In a sense, a manager is a physician-in-residence to a business. When the business gets sick, he is supposed to know what to do to make it well again. Some people have a natural talent for the job; but I think that in the future reliance must be placed largely on people with only moderate ability, using efficient tools. One of the most efficient and versatile of these tools is the control chart, a device ordinarily applied to quality control right on the job. But an even more important use in the future will be to control all phases of factory operation — payroll, scrap, power consumption, inventory, sales, returns — every possible aspect of management. The factory manager of tomorrow will have a number of control charts on the wall of his office; his staff will have more. Each day they will go over these charts, as a doctor takes the pulse of a patient. One of the commonest criticisms of management today is that the front office doesn't know what goes on in the factory. Once management learns to use control charts, that won't be true any more.

Perhaps the most important change to be expected in the future of industry is an increasing demand for precise information. Many questions asked today are answered for the most part by methods whose reliability is at best an unknown quantity. The need is for better methods, especially methods for measuring the reliability of our conclusions; this means statistics. Only the statistical approach to estimation problems can provide limits of error, without which it can never be known

whether the safety factors should be ten or ten thousand per cent.

Especially is precise information needed in the field of product design. Few suppliers know in terms of quality what they are selling. Many of them have never devised any method for quality measurement. To far too great an extent factories are working in the dark, with no clearly defined objective except to make a profit. Industrial statistics has a big job in casting light upon these obscure paths.

The industrial statistician himself has a long way to go, and much to learn. Right now there are relatively few technical statisticians in the world capable of assuming what must eventually be the statisticians' responsibility. There is a demand for statistically trained scientists, engineers, and executives, as well as for adequate courses in statistics in our engineering and technical schools. A serious bottleneck is teachers; relatively few of our present statistics teachers have the engineering and manufacturing background for teaching industrial statistics successfully. Industry can help here by making outstandingly successful men available to local institutions for part-time teaching or special lectures.

It would be silly to suggest that all we need to do to save industry from ruin, and democracy from collapse, is to turn all our business over to statisticians. It would be sillier for any responsible executive to hazard his business with an unknown and untried method, or to place in a position of great responsibility and authority an untried individual. No such proposal is implied in this discussion, but the intention is to suggest as strongly as possible that the men of demonstrated ability in industry today become acquainted with the statistical approach to management problems and explore its possibilities. This of itself will not protect industry or save democracy, but it should help, on the basis that statistics is, or ought to be, nothing but measured information tempered by commonsense. If this information is used to formulate realistic policies, if enough leaders think clearly and provide initiative, then the present can look at the future, if not with confidence, at least with hope, and certainly can proceed with courage.

A Complete Quality Control Program

JOSEPH MANUELE

DIRECTOR OF QUALITY CONTROL, WESTINGHOUSE ELECTRIC CORPORATION

[**Presented at Morning Session, March 5**]

Quality control implies the control of quality at some predetermined level as contrasted to inspection, which is a post mortem operation. Any attempt to control quality, automatically includes a decision as to the quality level. While perfection is desirable, it is not possible to attain. Even though the attainment of this perfection were possible from a manufacturing point of view, it would not be desirable, in all cases, to do so; in many instances costs would be prohibitive.

Therefore, at the very outset, a desirable quality level must be established — shall it be ½% defectives, 2% defectives, or 5% defectives? This level of quality must be determined after due consideration of the relative costs of maintaining a higher level of quality as compared to the losses which might be incurred from a lower level. The factors to be considered in making this decision will be different in different cases.

Having made this analysis and having determined on proper levels of quality for the different items being made, it will be found that some operations result in products which are satisfactory, or which meet the quality standard established. Obviously, in the interest of lowest cost, there is no need to put controls on such operations. However, there are operations which result in a higher level of per cent defectives than is desirable. The problem, then, is to determine, factually, which of the operations are satisfactory and on which operations it is necessary to establish controls. We say "determine factually" because many factory executives "know" which operations are out of control, but they have no records to substantiate this "knowing." In many cases, records would present a different picture. The first step, therefore, is to collect some accurate records. A simple single-sampling plan will accomplish this.

To establish a quality control pogram for a complete plant or department, it is necessary that provision be made for all contingencies and that the program be designed to give control over all items or products manufactured in that plant. The best procedure for determining this is to sample all lots produced in the plant. For this purpose, it is necessary that a simple though complete sampling plan be designed. The sampling plan must have two features:

(1) It must provide for different levels of quality, depending on the particular quality level desired in any item. Convenient levels of quality for parts or sub-assemblies are ½%, 1%, 2% and 5% defectives allowable.

(2) As a second characteristic a sampling plan must be understandable by the inspector who is to use it. This means that the instructions for use of the plan must be reduced to barest fundamentals.

The sampling plan may be issued to the inspectors in the form of a "System Letter" as shown in Figure 1. It will be noted that the information is given in the form of tables (only one of which appears in Figure 1) and not in the form of curves or charts. Inspectors with limited education, especially female inspectors, can use tables more readily than charts.

As an adjunct to the proper functioning of a sampling plan, it is necessary that the results of sampling be recorded systematically and in a uniform manner, preferably on a printed card, as shown in Figure 2.

The sampling plan must provide for definite action to be taken on each and every lot sampled. The sampling plan must allow for passing nearly all satisfactory lots. The plan must also provide for action on the rejected lots. The first action to be taken on rejected lots is detail inspection. The results of this detail inspection must be recorded on the record card showing the number of pieces detailed, the number of pieces defective, and the percent defective. The card should also show by means of notes the nature of these defects.

The second action which must be taken on all rejected lots is to place controls on the process so that the quality level can be raised to the desired value. There are two convenient methods for controlling the quality of products.

For short runs and those operations not involving tool wear or close control of quality characteristics, first piece and patrol inspection has been found to be economical and effective. Essentially, first piece inspection involves the checking of a few pieces by the inspector to determine whether or not

(a) the operator really understands what is required
(b) the tools will poduce parts of the required quality, and
(c) the operator has the skill to produce parts of the desired level of quality. This is particularly true in the case of assemblies where the assembler must make adjustments to the assembly he is putting together.

SIMPLIFIED SAMPLING TABLES — PLAN "A"

When parts are received, or are produced, in quantities it is always desirable to detemine the quality of a lot of such parts. This can be done by inspecting the parts 100%, which is relatively a slow and expensive operation, or by scientific sampling of the parts. The tables forming a part of this Systems Letter are designed for the latter purpose.

The tables have been calculated to pass lots according to different percentages of defective parts allowed "in the long run." They also show a degree of risk of accepting individual lots containing a percentage defective higher than that desirable.

As an example, let us suppose that we have a lot of 1325 parts of a particular drawing and item. The first decision that we must make is **what percentage of defective parts we will accept in the long run.** Let us assume that we do not want more than 1% defective parts. Then we refer to Sampling Table 2, 1% Defective Allowable.

Since we have 1325 parts, reference to the table will show that we must take a sample of 230 parts. We proceed to inspect these 230 parts very carefully, and if we find **three defective parts or less** we will accept the entire lot. If we find four or more defective parts, we reject the lot, and we will either detail the lot or return it to the supplier.

This procedure assures us that **in the long run** the number of defective parts in accepted lots will not exceed 1%. However, we note in the column headed "Risk of Accepting Lots 3% Defective" there is the figure .09 opposite sample size 230. This means that we might accept a **single lot** which contains as much as **3% defective** parts about 9% of the time, or about one time in eleven.

Use of these tables will reduce inspection costs and assure better quality of parts by putting the inspection where it belongs: on lots containing a high percentage of defective parts.

In order to make the most efficient use of these tables, the results of inspection should be recorded on a suitable form. A suggested form is attached to and forms a part of this Systems Letter.

SAMPLING TABLE 2 — 1% DEFECTIVE ALLOWABLE

1. Lot Size	2. Sample Size	3. No. Defective Allowed in Sample	4. Risk of Accepting a Lot 3% Defective
200 — 300	115	1	.13
301 — 500	170	2	.11
501 — 1000	220	3	.10
1001 — 2000	230	3	.09
2001 — 3000	240	3	.08
3001 — 4000	290	4	.05
4001 — 5000	300	4	.05
5001 — 7000	345	5	.05
7001 — 10000	395	6	.04
10001 — 20000	460	7	.03
20001 — 50000	540	8	.02
50001 — 100000	640	9	.01

Figure 1—QUALITY CONTROL SYSTEMS LETTER NO. 45.2
SIMPLIFIED SAMPLING TABLE 2 — PLAN "A"

The results of "first piece" inspection may be conveniently recorded on a tag designed for this purpose. This tag made out by the inspector attests to the fact that he has examined the setup and the first few pieces produced, and that in his opinion these parts are of the proper quality.

If necessary, the inspector can inspect parts produced at regular intervals to determine whether or not the desired level of quality is maintained. The responsibility for this periodic inspection is pretty much in the hands of the inspector, who uses his judgment as to how often to inspect parts and with what thoroughness this inspection should be done. His aim is to maintain a proper level of quality with the minimum amount of inspection. When he feels that changes have taken place in the setup or tools which might result in lowering of the desired quality level, he causes the operation to be shut down and proper adjustments made to restore the quality level, such as sharpening tools or issuing new instructions to assemblers doing bench work.

The second method of controlling quality is by use of the conventional statistical control chart. This chart may be the p chart, c chart, $\overline{X}$ and R, or whatever is deemed to be the most effective form. The control chart is more effective for controlling the quality of hard-to-make items or items which have quality characteristics which must be held within very close limits.

Returning to the record of sampling results, Figure 2, experience shows that these records should be reviewed daily by a statistician with the aim of determining any irregularity in the level of quality of any item from lot to lot. He should also look for lots which are consistently good and accepted every time they come up for sampling. For example, if ten consecutive lots of the same item are passed, it is desirable to initiate a program of reduced sampling for that item. Figure 3 shows Systems Letter No. 46.1 covering instructions for reduced single-sampling, and one of the four tables accompanying this letter.

SIMPLIFIED SAMPLING TABLES — PLAN "B" — REDUCED SAMPLING

Sampling Plan "B" is a supplement to Quality Control Systems Letter No. 45.2, commonly referred to as Sampling Plan "A".

The recommended procedure for using Sampling Plan "B" is as follows:

If ten consecutive lots of an item pass Plan "A", change to Plan "B". If an item which is on Plan "B" fails the plan, even for a single lot, go back to Plan "A".

In Plan "B" the amount of inspection required is less than half of that required by Plan "A". The average quality of material accepted by Plan "B" is the same as that accepted by Plan "A", in the long run. However, the risk of accepting a single lot of inferior quality is greater with Plan "B" than with Plan "A". On the other hand, Plan "B" is not used until there is some assurance of uniform high quality; viz, ten consecutive lots of a particular item have been passed by Plan "A".

As an example of the use of Plan "B", suppose that ten consecutive lots of a certain item have passed Plan "A". Suppose, further, that we have a lot of 1325 parts. Let us assume that our allowable fraction defective for this item is 1%. We then refer to "Sampling Table 2, 1% Defective Allowable," in Sampling Plan "B", Quality Control Systems Letter No. 46.1.

Since we have 1325 parts, reference to the table will show that we must take a sample of 95 parts. We proceed to inspect these 95 parts very carefully. If we find **one defective part** or less we will accept the entire lot. If we find two or more defective parts we reject the lot, and either detail or return it to the supplier. Moreover, **for subsequent lots of this part, we go back to plan A until ten consecutive lots again pass inspection.**

This procedure assures us that **in the long run** the number of defective parts in accepted lots will not exceed 1%. However, we note in the column headed "Risk of Accepting a Lot 5% Defective" there is the figure .05 opposite sample size 95. This means that we might accept a **single lot** which contains as many as **5 % defective** parts about 5% of the time, or about one time in twenty.

REDUCED SAMPLING TABLE 2 — 1% DEFECTIVE ALLOWABLE

1. Lot Size	2. Sample Size	3. No. Defective Allowed in Sample	4. Risk of Accepting a Lot 5% Defective
200 — 300	70	1	.13
301 — 500	80	1	.09
501 — 1000	87	1	.07
1001 — 2000	95	1	.05
2001 — 3000	125	2	.05
3001 — 4000	132	2	.04
4001 — 5000	140	2	.03
5001 — 7000	148	2	.02
7001 — 10000	180	3	.02
10001 — 20000	190	3	.01
20001 — 50000	200	3	.01
50001 — 100000	210	3	.007

Figure 3—QUALITY CONTROL SYSTEMS LETTER NO. 46.1 — REDUCED SAMPLING. SIMPLIFIED SAMPLING TABLE 2—PLAN "B"

In order for the plant manager or the superintendent, as well as the chief inspector, to get a complete picture of the quality performance of the plant, it is desirable to maintain a single chart on which is charted weekly the percent defective for the plant or department, as

shown in Figure 4. Some of the advantages of this complete program may be stated. Previous to the installation of this program, defects were running from 25% to 35%. After the program was in full operation, defects were reduced to an average of 1.35%. All of the inspectors on the second shift were eliminated. It was found that the first shift could adequately take care of the inspection.

Inspectors are now looking at all lots, whereas before the program was put into effect the policy was that "the wheel which squeaked the loudest got the grease." This meant 100% inspection of items on which complaints had been received from customer departments and, because of the limited number of inspectors, other lots were passed without inspection. Detail inspection of all lots was obviously out of the question.

The best results, however, are the intangible results of a more cordial relationship between inspectors and line supervisors because complaints are no longer received from customer departments. The program has resulted in better quality, increased production, and lower costs — items in which the line organization is definitely interested. There is every reason to believe that this program, which has been used successfully, is sufficiently flexible to be applicable in most manufacturing plants with comparable results.

DWG. NO. _____ ITEM NO. _____ STYLE NO. _____

NAME OF PART _____ USE SAMPLING PLAN A B

PART USED WITH _____

MANUFACTURING SECT. _____ CUSTOMER _____

DATE	LOT SIZE	SAMPLE SIZE	NO. DEFECTS	DISPOSITION OF LOT		RESULTS OF DETAILING		% DEF.	NOTES ON BACK
				ACCEPT	REJECT	NO DETAILED	NO DEF.		

Figure 2—FORM FOR RECORDING ALL SAMPLING AND DETAILING RESULTS

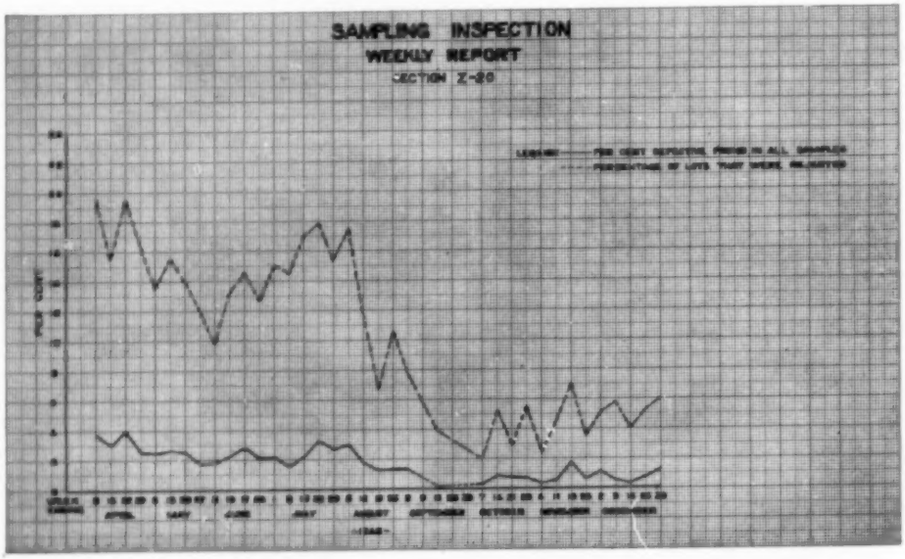


Figure 4—PER CENT DEFECTIVE CHART FOR PLANT MANAGER

Foundry Applications of Quality Control

WILLIAM M. ARMSTRONG

ONTARIO RESEARCH FOUNDATION

[**Presented at Afternoon Session, March 5**]

As your chairman has already stated, I am pinch-hitting for Dr. Westman of our organization. My own experience lies mainly in the fields of steel plant and foundry metallurgy, and it was as a consultant on metallurgical problems that I first became exposed to quality control methods.

In giving this report I shall, for reasons of time, omit many of the details of the difficulties which were encountered in our foundry applications. I would not, however, want anyone to get the impression that the application of quality control to a foundry is an easy matter —**it is not.**

The foundry, like many of the basic metal industries, is dependent to a large degree on human skills and would probably be classified

as a non-precision process. The work of a skilled melter, molder, or core maker cannot be recorded on a control chart and any attempt to do so usually arouses intense opposition. What can be done, however, is to control the quality of his raw material and the properties of his sand mixes, and to provide both workman and management with a factual measure of performance by studying the quality of the castings produced and the detailed causes of rejection.

The foundry application which will be discussed in most detail is the manufacture of manganese steel tank track shoes at Electric Steels Limited, in Cap de la Madeleine, Quebec. (This work was described previously by A. E. R. Westman and R. W. S. Freeman of the Ontario Research Foundation, in a paper published in **Canadian Metals and Metallurgical Industries, June 1945.**) This plant was designed for the express purpose of manufacturing 500-lb. cast steel bombs, but as larger bombs came into use it was converted to the production of manganese steel track shoes. Fortunately in this first foundry application only one type of casting and one grade of steel were being produced. However, the composition of the steel, the design of the casting, and the fact that most of the employees spoke only French did add considerably to the difficulties.

The shoe casting, which weighed about 20 lb. in the finished condition, may perhaps best be described as a designer's dream and a foundryman's nightmare. The large amount of geometry which has been incorporated in this part did little to aid in the production of a sound casting (see Figure 1). Also, the high manganese steel required is generally considered a problem child in any steel foundry because of its high coefficient of expansion and tendency towards shrinkage and cracking. Figure 2, which shows a simplified flow chart, provides a good outline of the manufacturing process.

It is only fair to say at this point that most of the conversion problems had been overcome before the advent of quality control. The daily production was between 2000 and 3000 shoes. However, the daily average of rejected shoes was about 20 per cent, and variations from five to forty per cent might occur within a few days. Incredible as it may sound, when a percentage chart was plotted for the few weeks prior to the introduction of quality control, not one point was within the control limits.

Figure 1—TANK SHOE CASTING

During the period of operation prior to this investigation some of the more important conditions had been studied and arrangements had been made to record many of the operating and inspection data. For example, it was known that pouring temperature was an important factor since high temperature could cause cracks and too low a temperature often led to cold shuts and gas holes. The following information was available: 1. Chemical analysis melting record and pouring practice of each heat. 2. Record of properties of each sand batch. 3. Plant inspection for defects by heats. 4. Government inspection records by days.

Starting from these initial data, modifications were introduced gradually as they became necessary. It was soon apparent that as much data as possible should be reported on a heat basis. Also, since the human element was obviously so important, it was necessary to plot certain data on a shift basis so that the records of different crews could be studied and compared. Inspection information was reported on a heat basis and broken down to show the causes for rejection in detail. The variables which were finally selected for study are shown in Table I. which is condensed from the paper by Westman and Freeman. Some 100 control charts were carried on

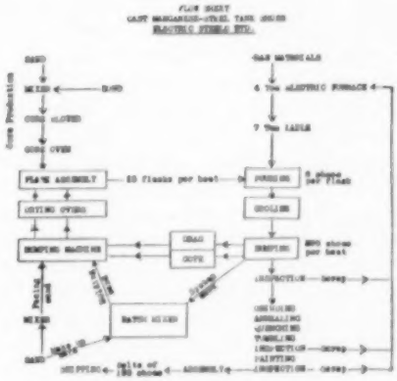


Figure 2: FLOW SHEET

by one senior man with inspection department training, and two untrained clerks. The senior man, who fortunately possessed a high degree of intelligence and was bilingual, spent much of his time checking accuracy of data, reporting to management, and following up action recommendations.

At an early stage of the process it was necessary to study the way in which the data were collected for each variable as well as the accuracy of these data. The changes made in the methods of temperature measurement will serve as an example of this type of investigation.

Gate freezing time was originally used as a measure of metal temperature, since the optical pyrometer was not suitable for high manganese steel. However, this time measurement was affected too strongly by personal judgment to be useful as a control factor. As a result it was necessary to design and build quick-immersion thermocouples for the measurement of both bath and ladle temperatures.

There is not time, at this session, to devote much attention to the details of the statistical methods employed. These were quite simple and could be generally understood by anyone who had received even elementary training in quality control methods. At the end of each week, data for the preceding two weeks were used to set center lines and control limits for the charts for the coming week. Different colors were used for each of the three shifts. At first this was on a time basis, but later on, to indicate a particular crew of men regardless of when they were working, since the make-up of the crew proved more important than the time of day.

The variables were plotted on long wall charts in such a way that all data for one heat were shown on the same vertical line. Many of the process changes resulted from close observation of these charts. However, the main purpose of control charts is to provide a measure of the variability of the process, and in foundries and steel plants the number of independent variables is too large for any but the most obvious inter-relationship to be detected in the above way.

It is more usual to establish the relative importance of each variable and the most desirable operating ranges by means of scatter diagrams and correlation calculations. Calculations of this type were used in this foundry application with very satisfactory results, but the fact should be emphasized that most of the quality improvements occurred when the operation variables reached a state of control.

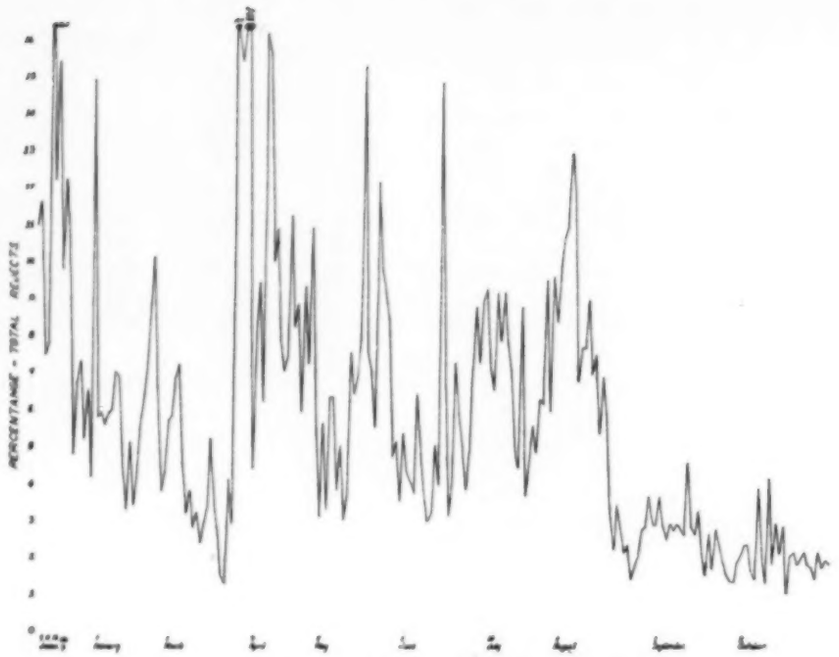


Figure 3—TOTAL REJECTS—CAST TANK SHOES

TABLE I

PROCESS AND PRODUCT VARIABLES UNDER OBSERVATION

A. Process variables
   1. Metal analysis (Mn, C, Si), slag (Mn, Fe0 content, lime-to-silica ratio).
   2. Sand (moulding, facing and core): green moisture, permeability and compression; dry permeability, compression and shear; hot tensile and deformation; 100 lb. collapsibility; retained strength; temperatures (mixing station, moulding station); clay content.
B. Melt and pouring practice
   1. Times: melting, refining, tapping, pouring, gate-freezing.
   2. Ratios: lime-to-spar, coke-to-spar.
   3. Temperatures: tapping, ladle.
C. Product variables (percentage rejection): total rejects, holes, cracks, gas holes, sand holes, core drop, cold shots.
D. Data bases: by heat, shift, batch, twice daily or weekly, every four hours.

Both single and double contingencies were made by means of the well-known chi-square test from scatter plots and other graphical forms. A significance level of $p = .05$ was used for all such calculations. This means, of course, that an apparently significant arrangement of points in the plot would be expected to occur by chance one time out of twenty, when there was actually no true relationship between the variables under investigation. Since contingencies were calculated for twenty or thirty variables each month, it was to be expected that at least one would show a p value as low as .05 by chance alone. For this reason there was generally hesitation about making any process change unless supported by further evidence in subsequent monthly calculations.

The control of silicon analysis will serve as an example of the use of contingency calculations and the importance of process control.

It appeared from critical observation of the control charts that **as a general rule** the heats with a high percentage of gas holes also had a low silicon content and vice versa. This relationship became quite apparent when contingency calculations were made. However, the control of the process was so poor in the early stages that the silicon level could not be arbitrarily raised. The specification for silicon was 1.00 per cent maximum, and heats containing over 1.00 per cent were rejected by government inspectors. It was usual to aim at 0.50 per cent and expect to get from 0.35 to at least 1.00 per cent. This range was gradually reduced as the melting variables were brought into control. Also, a rapid method of silicon analysis was developed which permitted tests to be taken from the bath during the refining period and reported before the heat was tapped. It was finally possible to aim at 0.80 per cent silicon and expect to fall within limits of 0.75 to 0.85 per cent.

The progress in reducing the percentage of defective shoes is shown in Figure 3.

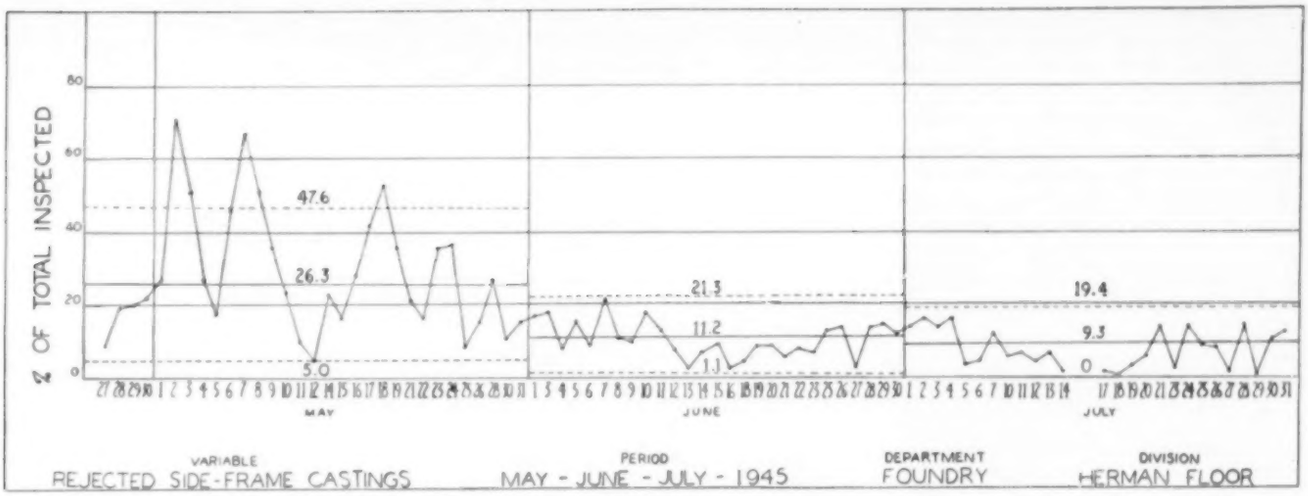


Figure 4—PER CENT REJECTION—DOMINION FOUNDRIES AND STEEL LTD.

A rule was in effect that heats showing over 33 per cent cracks would be totally scrapped, and this accounted for many of the high peaks in January and February 1944. The cause of cracking was largely eliminated by pouring temperature studies. In April an attempt was made to increase production by about 50 per cent in about a week's time without increases in equipment or workmen, with the result shown. In May some very capable salesmen succeeded in introducing a little known binder into the facing sand which resulted in excessively high hot strength values with an immediate increase in the percentage of cracked shoes. In July the shifts were re-organized on the basis of a five-day week. In August the supervising staff was concentrating on another urgent production program and paid little attention to the track shoe control charts. During all the preceding period considerable difficulty was encountered in rousing the interest of the moulding division in quality control, but finally in September a definite effort was made to bring sand variables into better control and to standardize moulding practice. As a result, the percentage of rejected castings dropped to a low value and remained at that level for the duration of the contract.

Table II shows a breakdown of the quality improvements in terms of various defects.

It is usually difficult to place a dollar value on quality gains, but this plant was a crown company, and an accurate record of the effect of quality control was available. It was estimated that the total cost of the program over a period of about 18 months was $15,000 and that the net resultant savings to the Government were $300,000, i. e., a ratio of savings to cost of 20 to 1.

TABLE II

A COMPARISON OF THE EXTENT OF DEFECTIVE SHOES FOR TWO PERIODS.

Analysis of Defects	Week ending January 18, 1944	Week ending October 7, 1944
(a) Poured shot	0.18%	0.02%
(b) Cold shot	0.37	0.22
(c) Core drops	1.96	0.31
(d) Sand holes	2.14	0.93
(e) Gas holes	4.98	0.38
(f) Cracks	0.82	0.06
(g) Bad saw cut	0.02	0.05
(h) Double pin reject	3.45	0.07
Total Per Cent Defective	13.92	2.04

The same methods of control have since been used in other foundry applications:

1. A similar program was applied to the manufacture of cast mortar bombs at Electric Steels Limited at a later date with comparable gains in quality. This work was carried out by the plant staff with a minimum of outside assistance.
2. The writer is at present engaged on a Research Fellowship with Dominion Foundries and Steel Limited in Hamilton, Ontario, where attempts are being made to place all plant operations and products under quality control. The foundry produces a wide variety of jobbing and production castings ranging from 1 pound to 50 tons. Since many of the same sands are used in both jobbing and production work, it was decided to run daily average charts on the green properties of all sand mixes, and use the production castings as a quality index. Such castings as railway car side frames which are in continuous production are identified by serial numbers and closely inspected. A breakdown is maintained on the different causes of rejection. Charts are kept of the total scrap from each foundry floor with reasons, (see Figure 4).

Special inspection forms are used for the production castings. A

diagram of the casting appears at the top and the **type** and **location** of defects are recorded for each casting, thus providing factual data for investigations of trouble. On large non-repetitive jobs a careful report is made, including sketches and moulding practice. These form a valuable guide on future orders of similar castings.

In summary, success of any foundry quality control system depends mainly upon:

1. Accurate and complete data on both process and inspection variables. Serial, heat or batch numbers, and sketches of defects, if possible.
2. Inspection of castings in order of production to observe quality trends. Minimum time between collection of data and reporting of results.
3. Prompt reporting to the responsible department of the need for corrective action. Adequate backing by the authority of top management.
4. An educational program to explain the function of the quality control department, to develop standard practices and understanding of the control charts, to make men in production aware of the value of the information available, and to make the whole plant quality - minded. Attractive charts and a convenient location of the quality department help.
5. A quality department possessing, in addition to knowledge of statistical procedure, technical knowledge of the process, common sense, and an open mind toward process changes.

Since statistical methods have been worked out in simple standardized forms which require little or no understanding of the underlying theory, and since the application of quality control, at least in the early stages, only involves observation of existing practice, there is no valid argument against the application of these methods to many foundry industries. Experience indicates that quality control provides a means of improving manufacturing efficiency and reducing the proportion of defective castings.

The Future of Quality Control

GEORGE D. EDWARDS

DIRECTOR OF QUALITY ASSURANCE, BELL TELEPHONE LABORATORIES

[**Banquet Address, March 5**]

Applied quality control has been in effective use in a number of important industries for from ten to fifteen years. With that background of experience, it should be possible to identify some general trend in its development. We should be able to put the equivalent of some sort of limit lines around that trend, and thus gain some idea of the direction in which we are headed. This is the approach I propose to use.

I am not one of those who feel that on May 16, 1924, when Shewhart made the first proposal for a quality control chart, there was born any fundamental philosophy which was or is to shake the foundations of all scientific and management thinking and techniques. Nor do I believe that Shewhart himself thinks so. The principles involved in Shewhart's proposal, though not the control chart itself, had long been used.

For example, in making determinations of such physical constants as the velocity of light, the mass of the hydrogen atom, etc., by any particular method, statistics had already told when there would be little improvement in accuracy in estimating the value of the physical constant in question by including additional measurements made by that particular method. This sort of application of statistical principles, and similar applications to the design of experiments, appear to me to offer one of the most promising fields for future work along statistical lines. They may frequently involve use of the control chart.

But such applications are not quality control. They do not result in a succession of articles of commerce, each such article having characteristics more nearly like its fellows' and more nearly approximating the designer's intent, than would be the case if the application were not made. To me, any procedure, statistical or otherwise, which has the result I have just mentioned, is quality control, and any procedure which does not have this result, is not quality control. From this point of view, quality control has been used ever since man began making articles in any quantity. The refinement of the quality control in any case is measured by the degree to which this result is attained, and not by the refinement of the procedure, statistical or otherwise, which has been used in attaining it.

Eliminating causes of variations and changing processes to turn out a better product constitutes 90% or 95% of quality control, and there is little if anything about them which can be accused of being statistical. Their accomplishment requires exercise of that imagination, that keen discernment of cause and effect, and that intuitive knowledge of the production

process, all of which go with successful management of any factory. The remaining 5% to 10% of the quality control job is frequently accomplished with the aid of statistics, but all it ever does is to tell us when we need to go to work on the 90% to 95% part. Even the 5% to 10% part is usually a combination of statistics with quite a lot of good horse sense. I don't mean to discount the importance of the theoretical, but in the relatively rare cases when we do need more than pretty nearly the simplest of basic theory, we need far more knowledge of it than most ordinary quality control men can possibly carry around with them, and we will nearly always be forced to turn to the theoretical expert.

To my mind, the practical quality control man should make sure that he acquires the necessary basic mathematical and statistical principles. Thereafter, he could profitably devote as much of his time as possible to acquiring skill and facility through actual experience in running down causes of demonstrated quality variations in going production processes. There is no substitute for this sort of skill in a good quality control man, and it can only be acquired by actually doing it over and over again in as wide a variety of processes and operating conditions as possible. Men with this skill highly developed are scarcer than hens' teeth, and they are pretty likely to continue to be, whereas men with merely the ability to do the 5% to 10% part of the quality control job usually thought of as statistical, are likely to be a dime a dozen in the period immediately ahead. I fully appreciate that this sort of talk about long, hard, hand-soiling, work tends to take the glamour out of the job, but I think someone needs to say it in the present state of things, and to say it as impressively as possible.

When we attempt to control quality on an attributes basis, sampling tables become one of our very necessary tools. The sampling table tells us how large a sample to take, and having inspected the sample, what to do with the lot from which the sample came, whether or not we need to do anything about the process from which it came, and how large a sample we must take from the next lot.

The simplest kind of such tables are single-sampling tables. Single-sampling tables are the easiest to administer, and they involve almost no variation in the inspection load. In frequency of use, however, single-sampling tables are today largely overshadowed by double - sampling tables. Yet double-sampling substantially complicates the inspection job. Errors are more likely to occur in operating it, even with relatively experienced inspectors and it certainly does mess up the inspection load. It is my humble guess that the psychological factor — the fact that the questionable lot gets a second chance to get by — accounts for 75% to 90% of the cases where double-sampling is being used today. In the remainder of the cases, double-sampling proves in on its own, because the saving offsets the additional complication involved.

The fact that the amount of inspection is reduced as the number of samples is increased has intrigued sampling theorists for years. They have realized that as we go from double-sampling to triple, from triple-sampling to quadruple, etc., the increase in saving becomes less with each additional sample, but the total saving from a considerable number of samples has always looked as though it should add up to something pretty substantial.

Some rather extravagant statements have been made as to the savings that reside in multiple sampling, or in sequential sampling, as multiple sampling figured out in accordance with Dr. Wald's theory has frequently been called. Most such statements spring largely from theoretical considerations, and result from comparing multiple or sequential schemes involving small first samples and a considerable number of samples, with single or double-sampling schemes involving relatively large first samples. Actually, the size of the first sample is pretty much the key to the whole situation. If comparisons are made between multiple and double plans both using the same first-sample size, the differences in operating characteristics can then be stacked up against the differences in amount of inspection required, and a reasonably intelligent decision can be made. Also, this leaves the first-sample size to be settled as it should be, by consideration of representativeness, process-average-determination, and other quality control factors.

If I were to venture a guess as to the future of multiple sampling, and therefore of sequential sampling, it would be that certain areas of the inspection job will probably gradually define themselves where multiple sampling will be the most effective approach to a solution. My own guess would be that these areas would probably not comprise a very large proportion of the total field, perhaps 5% to 15%, but that their relative importance might be considerably greater than that proportion.

From the standpoint of the quality control man, one factor which has handicapped his use of multiple sampling has been the lack of entirely satisfactory operational procedures for varying the amount of inspection and the severity of the acceptance criteria as changes are experienced in the level and degree of control actually shown by the product. These considerations are of course somewhat of a negation of the discrete-lot approach on which the sequential sampling theory is based. Frankly, I believe some way will eventually be found to reconcile these apparent differences, and that multiple sampling will ultimately take its proper place as one of the important tools of the quality control man.

Let us return to consideration of the quality control chart. The big gripe about it has always been that it takes time to prepare and keep up, that it costs money. I think that gripe is gradually solving itself. Seldom, today, do we see a control chart being maintained in connection with attributes inspection. I think this is in general a perfectly sound tendency. There are frequently attributes inspections, of course, in connection with which a control chart is most helpful, but in the vast majority of such cases, the acceptance number of the sampling table is a perfectly satisfactory approximation to the limit line of the control chart, and it will serve quite well as an indication that it is time to start on the 90% part of the quality control job, that is, to start looking

for trouble in the production process. I think we may expect in the future an enormous increase in the use of attributes control with statistically sound sampling tables, using no control chart whatever, but using merely lot rejection experience as an indication of when to start chasing causes of quality variations. I think we will see a constantly increasing proportion of our mass production controlled in this way during the post-war years because its operation is so simple and so effective. Ordinarily it effects such a large proportion of the total inspection savings and of the total quality improvement possible with more refined plans that there will be, as there already has been, a tendency to use it even under conditions where a more refined procedure would be more economical.

As our use of attributes control increases, we must be constantly on the alert for situations where variables control would be enough more effective to justify its use instead. This will nearly always be the case where inspections are destructive, or where individual tests, even of an attributes type, are very expensive. But I am satisfied that there is also a very substantial field in which attributes control is now used, or in which there will be a tendency to use it, where the additional effectiveness and inspection saving possible would amply justify the use of variables control instead. Cases involving tool-wear, or involving gradual loss of tool adjustment, for example, may be particularly susceptible to effective application of variables control. If we are careful to introduce variables control gradually wherever it is economical, I think we may expect by the very nature of things that as our application of attributes control increases we will experience a corresponding, if not greater, proportional increase in our applications of variables control. Variables control nearly always involves use of the control chart, so it seems to me almost a foregone conclusion that we are going to see a gradual, but in time very large, increase in the number of control charts in effective use around manufacturing plants.

As in attributes control, we must place each of our variables control inspections at as early a point in the production process as possible. Having done this, we must keep our chart posting and analysis work constantly up to the minute. Most of the advantage of quality control is lost if, at the time we discover we are out of control, thousands of defective piece-parts or partial assemblies have already been produced which must be junked or reconditioned. This is bound to happen if our control inspection is at the end of the assembly-line, or if points are not plotted and appraised on the control chart until several days after the inspections are made.

Finally, we must not forget that the variables method provides us with an extremely sensitive touch on the pulse of the process, and that if we are to gain maximum advantage from it, we must provide simple operational procedures just as we do in attributes control for decreasing the amount of inspection, or for increasing the severity of our acceptance criteria, as changes are experienced in the level or degree of control actually shown by the product.

All of this points, I think, to the fact that our future successful quality control man has got to be an extremely versatile individual, that he will need a very thorough working knowledge of a lot of operational tools (some of which are basically statistical,) of the relation of those tools to each other, and of their relative power, usefulness, and economy, in various circumstances, even though he need not necessarily have too much knowledge of the theoretical background underlying those tools.

As to the directions in which we will progress, what I have indicated appears to be in line with what has happened in the past development of quality control applications, not only during the war years, but for a period of as much as ten years prior to the war. As to why I look for a large further increase in the application of quality control, I reply that sound quality control is economical, that particularly during the war years it had an opportunity to demonstrate that it is economical, and it did so demonstrate to a very large number of people in a wide variety of industries, and finally, that anything which is sound economically is bound to win out in the long run.

In the Bell Telephone System, for example, we have been using this approach and applying these principles successfully to the solution of actual process and acceptance quality problems for over twenty years in the procurement of thousands of different types of articles valued at hundreds of millions of dollars. Other industries have numbers of successful applications extending over periods of years and offering like testimony to the sound worth of quality control.

War procurement offered an unusual stimulus to further such applications. My own experience in this latter field was pretty much concentrated on acceptance control problems for the Ordnance Department and the Signal Corps of the Army. Here the value of the material involved was measured in billions of dollars instead of millions. The quality control approach provided a solution to a large number of pressing and troublesome inspection and acceptance problems in both Ordnance and Signal Corps to which there was no other solution, and which, if a solution had not been found, would have materially impeded our progress to victory.

I should emphasize at this point that it is seldom possible to express in dollars and cents any very large proportion of the advantages and savings which result from the introduction of quality control, and it is never possible to evaluate all of these advantages quantitatively. One can of course get quantitative evaluations of the resulting changes in rejection percentages, in percent rework, in scrap-loss, etc., but every enterprising management knows that these are simply measures of symptoms. It is the intangibles, representing fundamental causes of unsatisfactory shop performance which quality control attacks at their source. In general, the intangible advantages of quality control far outweigh the tangible ones, and it is practically impossible to express them in dollars and cents. The good quality control man must exert himself to avoid having his management predicate its quality control commitments on actual or potential savings in dollars and cents alone.

Rather, he should aim at convincing his superiors that good quality control is a necessary part of good management, and that good management is impossible without it.

Someone will ask where the quality control man will fit into the future ideal organization. I don't think it is possible to generalize on that question. The answer is bound to depend on personnel and other factors and conditions individual to each particular company. In one case, the quality control man may be set up as an advisory consultant to the design and production organizations. This is weak but it avoids trouble. If the quality control man doesn't succeed in "selling" his wares, top management will probably never know the difference. But under these conditions, the quality control man has no particular responsibility for the end result, and the lack of incentive will militate against his success. Nevertheless such a plan will be the only feasible one in some instances.

In other cases, it may be found desirable to establish a quality control department as a part of the manufacturing organization. This has the advantage of giving quality control definite duties and of providing an incentive to accomplishment. But it tends to make a policeman out of the quality control man, and it may lead to his involvement in operational problems of the shop which should be entirely in the hands of production personnel. Altogether I think this is perhaps the least promising of the possibilities, though there will doubtless be cases where it is the best one to use.

Another possibility is the establishment of quality control as a functional part of top management. This approach recognizes that good quality is not accidental, and that it does not result from mere wishful thinking, that it results rather from the planned and interlocked activities of all of the organizational parts of a company, that it enters into design, engineering, technical and quality preplanning, specification, production layout, standards, (both of workmanship and personnel), and even into the training and fostered point of view of administrative, supervisory, and production personnel. This approach means placing one of the officers of the company in charge of the quality control program in a position analogous to the comptroller or to the manager of operations. Its objective would be elimination of the "hunch" factors which at present so largely determine the product quality of too many companies. It would put the man at the head of the quality control program in a position to establish and make effective a company-wide policy with respect to quality, to direct that action be taken where it is necessary, and to place responsibility where it belongs in each instance. Such a proposal may sound a little radical to many, but it does place a top-management responsibility at top-management level.

I don't look for too many organizational set-ups of this last-mentioned kind immediately, though I suspect we will see a trend in this direction. But the important point is that competition in uniform and dependable quality is going to assume a more and more important place alongside of competition in cost and selling price, and the company which fails to work out some arrangement for securing effective quality control is bound, ultimately, to find itself faced with a kind of competition which it can no longer meet successfully.

Expanded application of quality control has wide and deep social implications in addition to the more purely economic ones I have mentioned. Our job has almost limitless possibilities, so far as each one of us individually is concerned, of contributing to the social and economic well-being of our country. If we conduct ourselves and our work efficiently and effectively we shall deserve a reasonable share in the fruits of our country's economy, and we shall each of us have a fair chance of securing his part of that share in proportion to his own contribution. I'm sure that's what we are all looking for, and what we can expect only under our American system of private enterprise in a free economy.

NOTICE

The next report of the Midwest Quality Control Conference will appear in the July issue. Additional copies of this issue can be obtained at a price of $1.00. The complete Conference report will be available at a price of $4.00. Requests for individual copies or for reservation of complete sets should be sent to Martin A. Brumbaugh, Crosby Hall, University of Buffalo, Buffalo 14. Payment should accompany orders for individual copies. In placing orders for the complete report, please give mailing address so that we can send bill when the set is ready, either in December, 1946 or January, 1947.

LIMITS FOR CONTROL CHARTS

Second Article

PRESTON C. HAMMER - PROBITY ENGINEERS

In a paper published in the November 1945 issue of INDUSTRIAL QUALITY CONTROL (reference 1), the need for limitation of the use of the standard formulas for p-charts and c-charts was shown. The method described there called the moving range technique for setting limits has been used for a number of p-charts and c-charts. It is a pleasure to announce that this method has been placed on a sound theoretical basis by Professor Paul G. Hoel in a paper which will soon be published. The use of moving ranges by groups of two variates is considerably more efficient than the ordinary range by groups of two for estimating standard deviations.[1]

This article contains a discussion by means of two basic types of the application of the average and range chart methods to the analysis of measurements when several measurements are made on the same unit. In theoretical statistics these problems are treated by the analysis of variance technique. Although the control chart method is a simplification of some principles involved in the analysis of variance, it is often more effective in that the graphic presentation of measurements suggests reasons for changes and in that the history of a process is quickly evident to the eye — elements missing in the customary analysis of variance.[2]

The illustrations, although simple, will serve to point up the common error in setting average chart limits from the average range of non-rational sub-groups, i. e. sub-groups not representing all the sources of variability it is desirable to include. The illustrations will also show what may be done in several similar problems to make a useful analysis.

Why Repeated Measurements are Made

Repeated or multiple measurements are used when it is recognized that a single measurement may not yield sufficient information about the characteristic measured. The common assumption that one measurement is sufficient in some instances is the equivalent of assuming that the inspection of one unit of a lot determines the quality of the lot. Sometimes this point of view is the economic one to take, at other times it is based on an unfounded faith in the homogeneity of the unit or the lot. The question "how many measurements should be made of a single characteristic on one unit?" is on a parallel with the question "how many parts of a given lot should be inspected?"

The second question has received much more attention than the first.

The chemists have long recognized the need for several analyses of materials either to check their work or to detect non-homogeneity. Physicists and engineers make several determinations of the constants involved in their equations. Inspection procedures sometimes call for repeated measurements of a single quality characteristic. Specifications for process control (eg. spotwelding) are coming to be phrased in terms of averages and tolerable variations. The use of multiple measurements will increase, especially in analytical work.

Illustration 1: Random Multiple Measurements (Chemical Analysis)

To show how control charts may be effectively used when the several measurements on one quantity have no individual significance with respect to the quantity measured we have chosen a chemical analysis situation. To accomplish the analysis a representative portion of a batch is rendered homogeneous by mixing and from that homogenized portion three samples of practically the same weight are taken and analyzed for calcium content. We assume that the three samples are analyzed simultaneously by the same chemist so that the calcium percentages have no reference order. Let X_1, X_2, X_3 represent the percentages of calcium obtained from three samples from one batch. The indicated percentage of calcium in the batch is then $\overline{X} = (X_1 + X_2 + X_3)/3$. (Note that this average of percentages is permissible as we assumed that the samples had the same weight).

How shall we represent these data by means of control charts? It is clear that the range R of X_1, X_2, X_3 is of interest as it affords a measure of the consistency or precision of the process of analysis (not, however a measure of its accuracy). The R-chart with limits set as usual is a natural one to use. The indicated calcium percentage, $\overline{X}$, for a batch, may also be used to form another chart. The limits for the $\overline{X}$-chart may **not** be set using $\overline{R}$, for $\overline{R}$ is a measure of the average variability in the process of analysis but it does not measure variations in calcium percentages from batch to batch. In order to set three sigma limits for the $\overline{X}$ chart we must obtain a measure of the variability from the values of

(1) (Editorial Note) Readers acquainted with theoretical statistics will be aware that for a controlled process the use of average ranges or average standard deviations from small sub-groups is a considerably less efficient means of estimating the process standard deviation than the use of the standard deviation calculated from the combined sample obtained by pooling all the sub-groups. But it must be remembered that for a process not in control, the only means we have for estimating the inherent process variability is from rational sub-groups in which assignable causes are not operative. The efficiency of an estimate is measured by the reciprocal of the average squared error of estimate. —C. C. Craig

(2) (Editorial Note) Actually the principles underlying the $\overline{X}$ chart and R chart or σ chart and a two-component analysis of variance are essentially the same; — a comparison of within sample variation with between sample variation. But the ways in which the comparison is made differ somewhat both having advantages, with the control chart method having the important ones mentioned by Dr. Hammer. —C. C. Craig

$\bar{X}$. The moving range method by groups of two successive values of $\bar{X}$ is quite likely to be suitable. Denoting the moving range by R_m the $\bar{X}$-chart limits are $\bar{\bar{X}} \pm \sqrt{2}\ A_2\bar{R}_m = \bar{\bar{X}} \pm 2.65\bar{R}_m$. Limits set in this fashion on as few as twelve values of $\bar{X}$ have been found useful although twenty or more values are preferable.

Assuming, as we have, that the variations within three analyses of one batch are independent of the variations in calcium percentages from batch to batch we may write for a controlled process

(1) $\sigma_x^2 = \sigma_a^2 + \sigma_b^2$

where σ_x is the standard deviation of the frequency distribution of the individual percentages, σ_a is the measure of variability due to the process of analysis, and σ_b is the standard deviation of the $\bar{X}$ frequency distribution.[3]

Then σ_a is estimated by $\bar{R}/d_2$ (for sample size 3) and σ_b by $2.65\bar{R}_m/3$. It is frequently a practice of chemists to assume that if two percentages are close to each other and the third is not in such close agreement that the third value is an error and it is omitted from the calculation of the average. We conclude that this practice is not justified if the range R is below the upper control limit whether the limit be set at the usual 3-sigma level or at any other prescribed level.

A percentage could be discarded if it falls outside $\bar{\bar{X}} \pm 3\sigma_x$ where σ_x is computed from equation (1) and if the other two percentages fall within $\bar{\bar{X}} \pm 3\sigma_x$, **and** the range falls outside the upper range control limit.

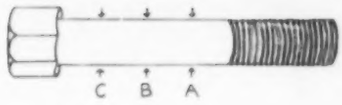
The equation (1) has another important use. It serves to indicate whether or not the method of chemical analysis is adequate for the particular problem. If σ_a is quite small in comparison to σ_b perhaps a more economical process of analysis would be sufficient. A more economical analysis might involve reducing the number of analyses per batch or using a less accurate method to perform the analyses. If σ_x is too large the decision as to which contributing factors must be more closely controlled can be based partially on the information afforded by equation (1).

The method for handling the $\bar{X}$-values suggested is not the only one which may be followed. The $\bar{X}$-values may be considered as primary data and averages of groups of these values charted along with the corresponding ranges of these groups. Along this trend of thought a weighted moving average of $\bar{X}$-values as described in (reference 1) would serve the double purpose of narrower limits and emphasis on the value for the current batch. The only point which must be insisted upon is that in this case the variability of the $\bar{X}$'s is compounded both of analysis errors and of batch-to-batch variation and therefore the ranges of X_1, X_2, X_3 are not suitable for establishing limits on the $\bar{X}$-chart unless σ_b is negligible in comparison to σ_a.

Illustration 2. Ordered Multiple Measurements

If the measurements made of a quantity are designed so as to have some special meaning with reference to the process resulting in the characteristic measured we shall term these measurements ordered. For example, in the chemical analysis problem just discussed, if each analysis had been made by a different chemist then the percentages have a special reference and the data may be analyzed for differences between chemists. An application of the control chart methods to an inner diameter of which 4 located measurements were made on each part may be found in (reference 2). In (reference 2) the control chart limits for the average charts are subject to further analysis.

Consider the diameter of a steel bolt. Of all the possible measurements one might decide to take three readings of the diameter — one near the threads, one at the center of the bolt and one near the head. Denote these measurements by A, B, and C respectively (Figure 1).



We want to analyze these data using control charts. Suppose the bolts are measured in successive groups of 5. Then the computation form may be designated as shown in Figure 2.

First of all, we would make a chart of the ranges R_1 of A, B, C as this affords a measure of the variability of diameter on a single bolt combined with the variability in the process of measurement. The limits would be set as usual for sample size 3. A chart of the average of A, B, C which we call $\bar{X}_1$ is optional depending on circumstances. The moving range method gives $\bar{\bar{X}} \pm 2.65\ \bar{R}_m$ as limits where R_m is the moving range of successive sets of two values of $\bar{X}_1$. The $\bar{X}_1$-chart serves to aid in making machine settings and in showing trends of diameter from one bolt to the next. In case the groups of 5 bolts are measured quite frequently we may prefer to plot the average $\bar{X}$ of 5 $\bar{X}_1$ values and the range R, of the same group of $\bar{X}_1$ values. This is indicated by the two columns at the right. For this treatment, we still need the values of $\bar{X}_1$ from which to obtain the range R but the moving range R_m may be dispensed with.

To this point the present illustration differs in no essential from illustration 1. We have not yet made an analysis to reveal the differences present (if any) among the measurements A, B, C. Two methods are at hand, using the average and range chart methods. The first method would consist in making a set of average and range charts for each A, B, and C. In this case limits would be set as usual. This form of presentation is not suitable for bringing out comparisons between A, B, and C for each group of five bolts. To do this it is best to make an average chart containing $\bar{A}$, $\bar{B}$, $\bar{C}$ in succession for one group of bolts and then repeating the sequence for the next group. If three points representing $\bar{A}$, $\bar{B}$, $\bar{C}$ are connected with lines but not connected to the next group a good visual contrast is obtained to show up tendencies for

(3) (Editorial Note) It should be remembered that it is assumed here that each observed X in the same set X_1, X_2, X_3 is constant except for errors of analysis.

C. C. Craig

Piece No.	Measure A	B	C	R_1	$\bar{X}_1$	R_m	Average of $5\bar{X}_1$'s	Range of $5\bar{X}_1$'s
1	A_1	B_1	C_1	—	—			
2	A_2	B_2	C_2	—	—	—		
3	A_3	B_3	C_3	—	—	—		
4	A_4	B_4	C_4	—	—	—		
5	A_5	B_5	C_5	—	—	—	——	——
$\bar{X}_2$	—	—	—					
R_2	—	—	—					
6								
7								

Figure 2—COMPUTATION FORM FOR MOVING RANGE

one average, say, to be larger than the others. If we call this composite average chart the $\bar{X}_2$-chart the R_2-chart of corresponding ranges is made in the same fashion.

Now, for such a composite range chart the limits depend on the application. If the ranges R_2 vary independently of measurements A, B, C as we might expect in this illustration then $\bar{R}_2$ is a suitable value on which to base common limits for all the R_2's on the R_2 chart. If the ranges differ significantly for the three measurements then no one limit would actually be a three-sigma limit for all R_2-values. If the R_2-values differ significantly for the various measurements we need three average ranges and three upper limits so that it would perhaps be best to make three range charts and three average charts. On the other hand, if the ranges are independent of measurements our composite average chart still may present a problem. If $\bar{A}$, say, is consistently larger than $\bar{B}$, the limits for the average chart become a problem for we should need 3 sets of limits. In practice however some indication of control may often be obtained by using $\bar{\bar{X}}_2 \pm A_2\bar{R}_2$.

The analysis for differences between $\bar{A}$, $\bar{B}$, $\bar{C}$ and the corresponding ranges using the $\bar{X}$-chart and range chart depends on the importance of the problem. Three sets of average and range charts to show conditions of control and the composite average and range charts (perhaps **without** limits) to give a ready visual method of comparison would provide a complete system. If these charts reveal no noteworthy difference between measurements A, B, and C the charts should be discontinued. This does not mean that the three measurements should be no longer made. The three measurements should be kept up if the R_1-chart contains worthwhile information.

A Remark on Rational Subgroups

The multiple measurement analysis may be applied when the measurements are not made on the same unit. For example suppose 5 units are measured every hour and it is found that the average chart limits are too narrow. This means that variations are present in the production of the unit which are not present in and are not measured by the variation within the groups of 5 units measured. There may be situations in which it is not felt to be desirable or economical to try to remove these between-sample variations, supposing their nature to be understood, and that they belong to a constant cause system. In such cases a sensible procedure would be to construct limits which will include these variations as well. One way to do this would be to set the limits on the chart for averages from the average moving range of the $\bar{X}$-values. As in illustration 1, one could still keep a chart on the ranges of groups of five but now these groups of five would not be considered rational sub-groups for estimating the standard deviation of $\bar{X}$.

Conclusion

The average and range chart method when properly applied are valuable instruments for the analysis of quality data. In this analysis the moving range for setting limits may be used to advantage as well as the weighted moving average as discussed in (reference 1). The illustrations are indicative of many of the problems arising in quality control work. Many examples have come to our attention which are more complicated than those discussed. A complete treatment of multiple measurements must be left to the future.

References

1. Preston C. Hammer, "Limits for Control Charts," Industrial Quality Control V. 2 Nov. 1945, pp9-12
2. J. R. Crawford and P. C. Hammer "Statistical Quality Control at Lockheed" Quality Control Report No. 9 published by W.P.B., Carnegie Institute of Technology Quality Control Program, September 1945

Reports of the Rochester Clinics

CLINIC ONE

Subject: Starting a Quality Control System.

Chairman: Martin A. Brumbaugh, University of Buffalo, Buffalo, New York.

Reporter: Edward Becker, Taylor Instrument Companies.

Quality Control is a tool of management, yet in exceptional cases only will top management on its own initiative investigate the subject. Therefore, the initial impetus usually comes from someone in the organization who has investigated the subject. This may be the chief inspector or some other member of the inspection department, an engineer — design, process, methods, or tool, a production supervisor, a purchasing agent, an accountant, a personnel supervisor, or a statistician. Wherever this person is placed in the plant he should follow a fairly well defined procedure in launching a control program.

1. Take an inventory of scrap, rework, salvage, unsatisfactory processes, inadequate design, worn-out machinery, status of gauging equipment. Unsatisfactory conditions usually are uncovered by this inventory.
2. If so, a control program is in order.
3. Select an area or a product which can be improved without spending too much time and which promises to give results without employing complicated procedures.
4. Very commonly the first subject will be obvious from the inventory. It may be in receiving, in fabrication, in assembly, or in control of quality of finished product. This will, of course, vary from plant to plant.
5. As early as possible get a fairly close estimate of the production cost of the article or articles under present conditions.
6. Draw up an operating plan.
7. Get the approval of an immediate supervisor and make the project known as far up the staff ladder as support is certain, **but no further.**
8. Get cooperation of those who will work in the project. This should extend to line inspectors and operators.
9. Spend whatever time is necessary to become familiar with the production process, materials used, machine operations, inspection methods, available records, and any other pertinent information.
10. Analyze records of inspection. Either they are usable or they are not. If usable, go to work. If not, get records that are usable.
11. Analysis requires use of principles of statistical control. Be sure to be grounded in at least the elementary principles of the control chart and the application of the principles of probability to industrial production.
12. Early in the operating stage of a control installation, a corrective action committee should be established. The purpose is to make all plant functions that may be involved in a program of product improvement parties to the project from the beginning.

CLINIC TWO

Subject: Control of Quality in the Presence of Trends

Chairman: Paul Peach, Head, Industrial Section, Institute of Statistics, North Carolina State College, Raleigh, North Carolina.

Reporter: Donald Stevens, Camera Works, Eastman Kodak Co.

The so-called toolwear chart is really applicable wherever one or more known causes of variability are to be allowed to reside with the constant cause system. These assignable causes are provided for in either of two ways: (1) by using sloping control limits placed about a least squares (or estimated) line or curve fitted to the averages of the usual small samples; (2) by using modified limits for averages of subgroups, these limits being set in from the drawing tolerances. Perhaps the simplest method of setting modified limits is to come in $\bar{R}$ distance from each tolerance limit.

All of this procedure assumes that the natural tolerance of the machine process is much less than the drawing tolerance. It further assumes that the "toolwear" cycle is relatively long (at least several hours). Such information must be obtained approximately before one is justified in setting up the toolwear chart procedure. Indeed a certain amount of caution is in order, because the toolwear chart actually is a much less important instrument of control than is generally supposed.

CLINIC THREE

Subject: Keeping Up to Date in the Gaging Field

Chairman: Louis Mahlmeister of the Sheffield Gage Corporation, Dayton, Ohio

Reporter George Riess, Gleason Works.

Competition in the post-war period will require that industry carefully review its gaging methods from the standpoints of improved quality and reduced cost. In pre-war days, gage equipment in many plants consisted only of general equipment; such as a surface plate, height gage, vernier caliper, and micrometers. Special gages were fixed go-not-go snap gages.

During the war, tolerances on machined parts were reduced to the point where these older type gages were unsatisfactory. Differences in the inspector's sense of feel played a large part in the acceptance or rejection of parts inspected by these older methods. Various indicating types of gages have become absolutely necessary to eliminate this human variable.

These indicating gages include: (1) External comparators—mechanical, electrical, and electronic; (2) Electrical gages with colored light signals; (3) Internal measuring machines — mechanical and electrical; (4) Air gages for both internal and external measurements.

All of these gages, in addition to replacing the inspector's sense of feel, greatly magnify the dimensional variation between the part inspected and the master part (or gage block) used to set or calibrate the gage. These types of direct reading instruments are essential to Statistical Quality Control methods since the readings obtained by inspectors will show machine trends before the dimensions actually go outside of tolerance. To obtain

the maximum possible benefits, these gages should be installed at the machine producing the parts so that the machine operator as well as the inspector can check the parts produced and make corrections in the machine setting before large quantities of scrap are produced.

Two additional developments in the gaging field have been: (1) multiple dimension checking gages to check simultaneously several dimensions, and (2) automatic gaging machines to check or sort parts into various classifications automatically. These types of gages have reduced inspection costs on such high production items as ball bearings and ball races, automobile wrist pins, cam shafts, piston rings, etc.

CLINIC FOUR

Subject: Quality Control in the Chemical Industry

Chairman: Charles A. Bicking, Engineering Department, Hercules Powder Company, Wilmington, Delaware

Reporter: Halsey H. Kent, Camera Works, Eastman Kodak Company

Statistical Quality Control has been used in the Chemical Industry for a number of years, although comparatively little publicity has been given to such applications. Several examples were presented by the Chairman in support of this point of view.

Ordinary measurement control charts were used to analyze simple laboratory operations such as weighing and determination of physical characteristics. Operators were rated in accord with the average range and precision of averages of repeated determinations. These ratings proved to be a splendid index of laboratory ability. In general, new operators were more accurate than older ones on this elementary work.

An example was given regarding the formation of resins whereby control charts were first used on the process to prove the laboratory assumption that the desired limits can be held. In the chart displayed this point was proven to the satisfaction of the Production people. However, in doing this it was found that hourly controls were not sufficient to control the process and that ¼ hour readings were required. This chart was also used to compare results of the day and night shifts and act as an immediate warning when a change in the catalyst was required.

A novel idea was presented whereby the colors of red, yellow, and green were used as limits on the chart. Green indicated control and satisfactory progress, yellow indicated the danger line or shoulder of the road, as the example was made, and red indicated out of control or in the ditch.

Control, to be of the greatest advantage, should be done on the production floor at the reactor which is to produce the satisfactory or unsatisfactory work. It was pointed out that the regular control charts on different kettles used in a chemical process were set-up to control such conditions as viscosity, melting points, and color of finished products. These charts also were quick to point out differences between kettles or reactors on original installations; also quick to point out difficulty or any failure in process of such items as steam lines, entrance orifices, etc. of the kettles or reactors.

It was planned that in the process of procuring lots of formaldehyde the vendor submit their control checks with each carload. In checking the incoming material one example was cited where the results disagreed. Further investigation indicated that both results were correct at the time the samples were taken, yet the carload lot of material had passed through climatic conditions which had caused some evaporation. Subjection to cold had also caused a crystallization and settling out which made the material unsuitable for use.

CLINIC FIVE

Subject: Controlling Quality of Sub-assemblies

Chairman: Alfred J. Winterhalter, Quality Manager, Colonial Radio Corporation, Buffalo, New York

Reporter: Keith Ackley, Stromberg Carlson Co.

A sub-assembly may be defined loosely as the assembling together of two or more components that later will be used as a unit in the fabrication of the final product. The objective in laying out the work by sub-assemblies is the reduction of over-all costs. Since the purpose of most organizations is to make a profit, this profit is achieved by the margin between selling price and total costs. Minimum total cost is not necessarily achieved with minimum fraction defective of the product.

To achieve a product totally free of defectives, engineering, production, inspection, and material costs may be beyond all reason. On the other hand, if too little or no attention is paid to the defectives produced, repair, scrap, reinspection, and field replacement costs may eat up the profit that otherwise might be available. Somewhere between the two extremes of no defectives and unlimited defectives, a zone of minimum costs falls. The objective is to operate at this minimum. This can be accomplished by the several divisions of the organization working together and integrating their efforts.

Those operators concerned with sub-assembly inspection can aid in achieving the point of minimum costs by carefully reviewing the relation of the sub-assembly with the completed product. How much inspection is required on the sub-assembly? None? 100%? Sampling? These questions can be answered only by a careful analysis of each condition. The following case illustrates a method of procedure.

A major sub-assembly for years was 100% electrically tested following completion of the assembly. Since the unit in which the sub-assembly was used was 100% tested, the question was raised whether 100% testing of the sub-assembly is required. The first step was to obtain a cost analysis with 100% inspection: (1) Cost of 100% inspection; (2) Cost of repair of defective work; (3) Cost of reinspection of repaired work. The sum of these costs at several values of fraction defective indicates that the costs increase approximately proportional to the fraction defective of the material produced.

As a second step the costs relating to a sampling inspection of the unit were obtained. These are: (1) Cost of sampling inspection; (2) Cost of 100% inspection where indicated by the sample; (3) Cost of repair of defective units; (4) Cost of reinspection of defective units; (5) Cost of locating trouble in the main assembly caused by defective

sub-assemblies; (6) Cost of repairing defective sub-assemblies found in the main assembly. The sum of these costs at several values of fraction defective indicates that the costs are a minimum when no defectives are produced and increase until the costs exceed those of the 100% inspection.

In the case studied, the process average of the sub-assembly was slightly under 1% and the point where the sampling curve crossed the 100% curve was 6%. A sampling plan was used having an AQL of 1% and a lot tolerance of 6%. For this case a saving of $18 per day was effected by resorting to sampling inspection. It was not deemed wise to remove inspection on the sub-assembly entirely, since the possibility exists that trouble in epidemic proportions might crop up. As a considerable inventory of sub-assemblies is maintained, such an epidemic would result in a chaotic condition.

Application of the foregoing procedure to each case on hand will readily indicate when 100% inspection, sampling inspection, or no inspection may be used. Furthermore, if sampling inspection is decided on, the conditions required of the sampling plan are given.

CLINIC SIX

Subject: Increasing Your Effectiveness Through the Use of Forms

Chairman: Richard Eisenhart, Chief Inspector Instrument Division, Bausch and Lomb Optical Company, Rochester, New York

Assistants: Howard R. Bolton, Harrison Radiator Division, General Motors Corporation, Lockport, New York; Francis F. Darrow, Stromberg Carlson Company, Rochester, New York; J. Hawkes, Eastman Kodak Camera Works, Rochester, New York

Reporter: E. W. Moore, Ritter Company.

Mr. Bolton presented forms used in receiving, fabrication, assembly, and reporting to top management. Of special interest were: "Part Number Index of Vendor Quality," "Vendor Process Average," "Inspection Rate Per Hour," "Control of Fraction Defective and Number of Defects," "Efficiency Check," and "Service Core Leak Forms."

Mr. Darrow explained in detail many of the forms used by his Company in connection with the control of quality of product. Noteworthy were the forms: "Weekly inspection report assembly department," "Weekly inspection report, machine and miscellaneous assembly departments."

The high light of Mr. Darrow's talk was the exhibition and explanation of his request for salvage forms. This form is printed in six copy series, one for each of the departments involved. It starts to function with a quality control man on the job, once the part, assembly or material starts to go wrong, and follows through causes, corrections, scrap or salvage, responsibility and cost on to final and complete disposition.

Mr. Hawkes uniquely illustrated many of his Company's quality control charts with lantern slides. He gave concise and educational review of each form. Unusual were the forms: "Inspection procedure," with the holes punched on one end for master filing, "Material inspection report," "Quality control day and night," "Double sampling lot record," "Total number of defectives per 100 instruments," "Go and no go gaging chart."

Mr. Eisenhart finished the program by giving a complete display and description of many unusual charts and forms used at Bausch and Lomb Optical Company. Noteworthy were his charts: "Receiving inspection report," "Quality records," "Machine control chart," "Inspection record," "The IBM percent defective," "Daily production and quality of product."

CLINIC SEVEN

Subject: How to Introduce Quality Control to Top Management

Chairman: Frederick J. Halton, Assistant to the President, Deere and Company, Chicago, Illinois

Reporter: Wilbur Hiler, Camera Works, Eastman Kodak Co.

Sixty representatives of Top Management held a one-day executive meeting devoted entirely to the fundamentals of Quality Control, including a practice session of plotting control limits, etc. for various prearranged tables.

The ten top executives in each of the 13 factories were given similar two-day meetings.

One man was selected from each factory to attend the ten-day course at some university.

Upon completion of this course, he was required to join a local Quality Control Society, which in the Midwest, especially, serve as continuation schools with regular two-day meetings and intensive courses. He is encouraged also to affiliate with other technical societies.

With this man as a course organizer, "In Plant" training courses were held two hours each day for two weeks with separate courses for men of (1) supervisory level, (2) foremen level and (3) worker level. The courses consisted of (a) technical, (b) practical and (c) "own success" presentations. Outstanding course leaders were brought into the plant for these sessions. The result has been that all executives in Deere and Company are thoroughly familiar with quality control by statistical methods.

Outstanding examples of Quality Control accomplishments in foundries, rubber industry, etc, were cited. No job was considered too small or too large for Quality Control exploration. There are usually intangible, as well as tangible, benefits to be derived.

Quality control is the missing link between engineering, production and inspection. It takes the guess-work out of thinking what is correct, that so-called fifth sense of the operator and production foreman. Management is primarily interested in dollars and cents. In each organization there is one "spark-plug" whose opinions and decisions generally dominate the plant. He definitely should be sold first on quality control. Success or failure rests with the manner in which it is sold to him and to others.

CLINIC EIGHT

Subject: Quality Control Applied to Job Shop Production

Chairman: Ralph E. Wareham, Manager, New Products, National Photocolor Corporation, New York City, formerly director of Quality Control, General Electric Company

Reporter: Fred Nilsen, Taylor Instrument, Companies.

Quality Control in small production is a highly controversial subject. Nevertheless variability must be expected regardless of the size of the lot.

In order to obtain a uniform final product, controls must be operative on raw materials and subassemblies as well as final assemblies. Three variables must be controlled: materials, machines, and men.

In order to isolate the problem in this group three types of production were listed: (1) Constant flow of same product in large quantities —(mass production); (2) Use of same facilities to produce different products at different times; (3) Different products produced with different facilities. The last two classifications were considered job shop production. Suggestions in methods of controlling the three variables were noted.

To control materials, first determine the quality level required of purchased raw materials. Keep accurate records of the quality supplied by different vendors to assist in determining from past quality the amount of inspection necessary. Keep records of causes of difficulty in production according to bottlenecks and extra man hours caused by defective materials and establish checks to prevent these losses.

To control machines, all tools should be checked as received to make sure parts made by these tools are correct. Periodic checks of parts should also be made to determine effect of wear on tools. Each machine used should be evaluated to determine its ability to duplicate. A preventive maintenance program should be practiced. Machines should be kept in repair rather than wait for breakdown before service is given them.

In operator control, the operator should be instructed whether to aim for the middle of the tolerance spread or move to one side. A chart posted above the machine for each operator showing his accuracy adds an incentive to keep his operation close to the nominal dimension.

CLINIC NINE

Subject: Sequential Analysis
Chairman: A. R. Jackson, Quality Control Consultant, Palumbo and Jackson, Chicago, Illinois
Reporter: John Matthews, Delco Appliance Division, General Motors.

The general background of sampling either in the receiving area or in production and assembly areas is the understanding that some defective materials will be accepted; that inspection personnel can be used more efficiently; that a good sampling plan will lead to as high quality as 100% inspection; that a good sampling plan requires random selection of the items to be included in the sample so as to insure that the sample will be representative of the lot. The preliminary work must include study of inspection methods, equipment, and instructions; knowledge of vendor's or production department's process average; agreement as to allowable fraction defective and satisfactory risks of rejecting good material or accepting poor material.

Exhaustive use of single and double sampling plans led to the conclusion that multiple (sequential) sampling would result in better quality at lower costs under a wide variety of operating conditions. It does not follow, however, that sequential sampling will always be preferred. The sequential plan does have the advantage of avoiding the necessity of establishing the vendor's process average in advance. Likewise it leads to slightly smaller samples in the long run than would be necessary under a standard double sampling plan.

CLINIC TEN

Subject: Controlling Surface Quality
Chairman: H. B. Shaper, Department Head, Instrument Division and Design, Brush Development Company, Cleveland, Ohio
Reporter: J. Frantz, Gleason Works.

With the introduction of Micro finish to industry, the measurement of surface roughness or surface quality became a major problem. The trend today is to make surface quality standard throughout all of industry so that no misunderstanding will arise between producer and purchaser when a certain surface quality is specified.

Surface roughness may be measured by the Sample Block Method. This method is one of the earliest and most inexpensive means used in surface quality classification. The technique is satisfactory and the method is one that has made some strides toward standardization through the production of sample blocks by several manufacturers that are available to all of industry.

Probably most familiar to all is the Sample Standard Method, in which surfaces are produced to agree with a sample surface that has been previously developed on a sample. This method exists only within a plant, or within several plants, having close and active association.

The procedure in which a pointer or stylus traced over the surface being checked (using a stylus and arm arrangement such as a profilometer) is called the Tracer Point Method, with the results in numbers or values being shown on charts or meters. These numbers can be used to determine an average surface value or (through the use of a formula, an HMS (Micro-Inch) value. A stylus with a point having a .0005 radius has been generally adopted by industry for use with this method, but the standard determining the value of Micro Inches still remains open to discussion.

Two other methods of measuring surface roughness are the Electron Microscope Method and the Taper Section Method, both usually confined to the laboratory.

The previously mentioned methods tell only part of the story of surface quality, namely that of wave or surface depth. The length of the wave can be determined by a photo electric cell or by the use of a 1/16" square stylus set in a fixed position while the part is moved under the stylus; the results being recorded electrically. This check is important because wave length plus wave depth determines the surface quality, each being of equal importance.

The Sample Block and Tracer Point Methods are now favored by the ASME and by SAE, but before definite conclusions have been reached and published, newer methods may be available to industry. There has been much study and research aimed at solving this

problem and some strides have been made in the right direction, but until some very definite standards are determined and put on drawings so that production, inspection, and engineering are in complete agreement, the problem will not be solved.

CLINIC ELEVEN

Subject: Quality Control in the Receiving Area

Chairman: E. F. Guilford, Chief Inspector, and R. W. Coolbaugh, Assistant Chief Inspector, Easy Washing Machine Company, Syracuse, New York

Reporter: Stanley Collins, Delco Appliance Division, General Motors.

The function of the receiving department is first accounting for the arrival of materials and second the determination of the quality of those materials. Today materials are received in large quantities. No vendor can always ship defect-free material; no receiving inspection plan, be it 100% or sample, can guarantee defect-free material at fabrication and assembly. The object is to set up a receiving plan which will insure a defined quality level going into manufacturing operations.

Acceptance of material excessively defective results in sub-assembly bottlenecks, assembly line slow down, operator - machine trouble, excessive toolwear and breakage, product failure, high service cost, dealer ill-will, and loss of markets. Avoid such contingencies by installing a good receiving inspection system. The fundamentals of such a system are: (1) Establish the economic breakeven point between the cost of more inspection and the cost of passing defective items; (2) Cooperate with the purchasing department on material and dimensional specifications, type of inspection, i.e. quality level required and how to insure it, gaging equipment and methods; (3) Cooperate with production control in getting materials through inspection to meet schedules; (4) Set up properly selected sampling plans and train the inspection staff in their correct use; (5) Prove by concrete results that quality begins in the receiving department.

SOCIETY REPORTS

SAINT LOUIS CHAPTER AMERICAN SOCIETY FOR QUALITY CONTROL

The Saint Louis Chapter was organized February 16 with the following officers: President: L. S. Kauffmann, Quality Control Director, American Stove Company; Vice President: Kort K. Pfabe, Assistant Chief Inspector, Carter Carburetor Corporation; Secretary-Treasurer: A. F. Madaus, Quality Control Supervisor, White-Rodgers Electric Company; Directors: J. H. Batchelor, Lecturer in Industrial Engineering, Washington University, and A. R. Burgess, Research Engineer, Amp Corporation.

This new chapter has 21 members in advance of any drive for members. It can look forward to continuous growth in the months ahead.

President Kauffman spoke at the March meeting on "Application of Statistical Methods to the Inspection of Porcelain Enamel." Secretary Madaus presented a composite report of the Midwest Quality Control Conference at the Chapter's March meeting. This report gave the members a very vivid picture of the plan of the Conference, and reproduced with precision the high lights of the papers presented at the general sessions and the sequence of four clinics which the author attended.

Director Batchelor spoke at the April 12 meeting on "Quality Control and Production Management." Professor Batchelor has a subject here which will be of interest to quality control operators as well as to men in the field of industrial engineering and management. The two are aiming at the same objective — better product at lower cost. The quality control operator has a method of approach to the solution of production problems. The production engineer has direct knowledge of the steps involved in corrective action. Much can come from cooperation between the two groups.

NEWARK SOCIETY FOR STATISTICAL QUALITY CONTROL

The March 14 meeting, devoted to "Quality Control in Penicillin," was a revelation to a large audience. Professor Bliss, Yale University, ably presented the statistical problem of control in a chemo-biological industry which is continuously in an experimental state. Discussion from the floor centered largely in assay methods, the critical production problem of the penicillin industry.

At the April 24 meeting, Mr. H. G. Romig, Bell Telephone Laboratories, spoke on "Administration and Engineering Aspects of Acceptance Sampling." He presented the most recent developments in principles of sampling and the operating basis for selecting among sampling plans that one best suited to a particular inspection task.

On May 23, Frederick J. Halton will speak on "Presenting Quality Control to Management."

INDIANA SOCIETY FOR STATISTICAL QUALITY CONTROL

At the February 12 meeting held at Purdue University Extension in Indianapolis, Mr. Louis R. Zimov, Crosley Corporation, reported on his company's production of the proximity fuse. His description of the fuse and its use in both the European and Pacific war theaters proved highly instructive. Control charts were maintained on all components produced in the plant, and close attention to evidences of trends even in advance of loss of control saved many man-hours that might otherwise have been spent in producing faulty material. At the same time the charting system reduced the cost of producing the fuse. Mr. Zimov pointed out that the radio tubes used in the fuse must meet very strict operating characteristic requirements, and that the only acceptable tubes were produced by a company which employs statistical control.

At the afternoon session, Mr. Harry Marsh, Perfect Circle Corporation, presented the statistical approach to the forecasting of automobile demand and supply. Messrs. Keith Ross and C. J. Herman reported on the Statistical Quality Control session of the A. I. E. E., January 24. Professor Irving Burr presented a paper on the use of sequential sampling with variables inspection.

QUALITY CONTROL ENGINEERS OF ROCHESTER

The regular monthly meeting of the Society was held at the Chamber of Commerce on March 19. This meeting consisted of a panel discussion with Mr. Alfred Davis acting as moderator. The panel was composed of the following: Mr. E. P. Mynott of Rochester Products Division, GMC, Mr. Fred Nielson of Taylor Instrument Company, Mr. William Myers of the Gleason Works and Mr. Larmonth of Walz and Krenzer.

Many interesting questions were presented and discussed at this meeting. These questions were sent in by members of the Quality Control Organization and dealt with actual experiences. All present felt that much good was done by a meeting of this kind and agreed to hold more similar type meetings.

The sub group on gage control held its regular meeting on April 1, at the Chamber of Commerce. Mr. Emmett W. Moore, Chief Tool Engineer of Ritter Company, Inc., was the speaker. His subject was the allocation of gage wear on plug thread gages.

Mr. W. L. Myers of Gleason Works and Mr. P. Fishbaugh of Graflex Company, were elected Chairman and Vice-Chairman respectively for the coming year.

ILLINOIS SOCIETY FOR QUALITY CONTROL

At the February 1 meeting, the following papers were presented: "Acceptance Sampling of Variables," Professor Irving W. Burr, Purdue University; "A Review of $\bar{X}$ and R Chart Theory," Professor John A. Henry, University of Illinois; "An Application of Quality Control to Hot Forging," Mr. H. I. Martin, John Deere Plow Works; "Quality Control at Le Tourneau," by the Quality Control Supervisor.

The next meeting will be held May 24 and 25 at Rockford, Illinois, and will be a joint meeting with the State University of Iowa Society.

DELAWARE QUALITY CONTROL SOCIETY

At the March 4 dinner meeting, Mr. C. A. Bicking, Hercules Powder Company, spoke on "Applications of Quality Control in the Chemical Industry." He included illustrations of the use of control technique in rating laboratory workers, in determining whether a resin producing operation could be held to predetermined quality variations, in cataloging significant differences in viscosity, melting points reduction kettles, and color of finished product.

At the April 1 dinner meeting, Professor Frederick Mosteller, Princeton University, presented "Run Theory as Applied to Quality Control Problems." All quality control operators recognize the existence of trends of points on control charts, and they know in general that such trends predict out of control conditions. But the technical basis for distinguishing a true run, i.e. a nonchance event, from what is often mistaken for a run, but is really a chance variation, was well brought out by Professor Mosteller.

SOCIETY FOR QUALITY CONTROL STATE UNIVERSITY OF IOWA GROUP

The March meeting of the Society for Quality Control — State University of Iowa Group was held in cooperation with the Chicago, Illinois, Indiana, and Northwestern societies in sponsoring the Midwest Quality Control Conference at La Salle Hotel, Chicago, Illinois, March 5-6, 1946.

The hypothesis that the conference was at least a mild success will be amply supported by evidence in various issues of INDUSTRIAL QUALITY CONTROL, the first installment appearing elsewhere in this issue.

The next bi-monthly meeting is to be May 24-25 at Barber-Colman, Rockford, Illinois.

CHICAGO SOCIETY FOR QUALITY CONTROL

Mr. Charles A. Bicking of the Hercules Powder Company, Wilmington, Delaware, spoke to the Chicago Society for Quality Control on April 10. He spoke to more than 130 members and guests on "The Application of Control Charts to the Control of General Administrative and Sales Expenses." Paid membership in the Chicago Society has exceeded 140, of which only six are members of the national society. A drive was launched to sign up all local members in the American Society for Quality Control. New local members will be requested to join the American Society for Quality Control at the same time they join the Chicago Society.

OHIO QUALITY CONTROL SOCIETY

The Society's annual meeting was held April 5 at Case School of Applied Science. The new officers are: President, C. R. Apthorp, Jr., Cleveland Twist Drill Company; Vice President, C. H. Beresford, Addressograph Multigraph Company; Secretary, R. Y. Barnes, Aluminum Company of America; Treasurer, R. J. Schager, Cleveland Graphite Bronze Company.

Mr. Wendell H. Abbott, General Electric, Nela Park Plant, spoke on "Introduction of Quality Control Principles to Advisory Personnel." His simple and direct approach to what is for many operators a perplexing problem proved to be quite valuable to a large attendance.

BOSTON SOCIETY FOR QUALITY CONTROL

At an all-day meeting held at Northeastern University on March 9, the Boston Society had as its principal speaker Mr. E. M. Schrock of Aberdeen Proving Grounds on 'The Quality Control Engineer."

A morning session featured talks by three of the members, sponsored by the Technical Paper Committee. Mr. M. W. Newcomb of American Bosch spoke on "A Training Program in Quality Control"; Mr. C. W. Kennedy of Federal Products presented "The Operator as a Partner in Quality Control"; and Mr. K. R. Bagley of Sylvania Electric Products, Salem, spoke on "Selection of a Sampling Inspection Plan for Adequate Protection at Reduced Cost."

Later in the afternoon, clinics were held as follows:

1. "Organizing, Integrating, and Maintaining Quality Control in Industrial Organization," Mr. F. G. Fales of Sylvania Electric Products, Inc., Salem.
2. "Sampling," Professor T. H. Brown of Harvard School of Business.
3. "Small Lot Quality Control," Mr. W. A. MacCrehan, General Electric Company, River Works.
4. "Machine Accuracy Studies," Mr. M. D. Benedict, General Electric Company, West Lynn Works.

On April 13, Professor J. M. Juran of New York University addressed the Society on the subject "The Management Problems of Quality Control" and Professor T. H. Brown of Harvard School of Business spoke on "Some Problems in Sampling."

Plans are made for the next meeting on June 8 at Northeastern University at which the membership will be addressed by Mr. George D. Edwards of Bell Telephone Laboratories, President of The American Society for Quality Control. Election of officers for 1946-47 will also be held at this meeting.

WESTERN MASSACHUSETTS SOCIETY FOR QUALITY CONTROL

The Western Massachusetts Quality Control Society was formed at a meeting held April 5 in Springfield. The principal speaker at this meeting was Joseph Manuele, Westinghouse Electric Corporation, East Pittsburgh, Pennsylvania. More than 60 persons attended and temporary officers were appointed to continue the organization of the new society. Messrs. Newcomb and Purcell of the Boston Society gave valuable assistance at this initial meeting.

SOCIETY OF QUALITY CONTROL ENGINEERS OF CALIFORNIA

At the Society's February 26 meeting, Dr. Preston C. Hammer, Probity Engineers, presented a paper, "Multiple Measurements." (Editor's Note: See page 20 for complete text). Mr. E. E. Bates spoke on "Presenting Quality Control to Management." He uses "t" charts, a combination of related "p" charts, to show the over-all quality level of a shop area or department, or of an assembly operation. This chart is useful for presenting results to management. It is not proposed as a corrective action chart. The "t" chart is also employed in reporting results of plant safety activities to management. There is some likelihood that the National Safety Council will adopt the control chart technique of analyzing accident data.

On April 11 the Society met at Hotel Clark in Los Angeles at a dinner in the Tropic Room. The general topic of the meeting was "Sampling." Mr. John M. Howell spoke on "A Resume' of Standard Methods," reviewing the operating characteristics of A. O. Q. L. sampling as presented by Dodge and Romig. Professor P. G. Hoel of University of California, Los Angeles, spoke on "A New Approach," a discussion of the operating characteristics of sequential sampling. Professor Hoel compared the characteristics of sequential with those of A. O. Q. L. sampling.

Mr. Wyatt H. Lewis gave a short report on the Midwest Quality Control Conference.

Elections were held for our representative to the American Society for Quality Control who will also represent the Western District of the United States on the Board of Directors. After a hotly contested election involving four candidates and five ballotings, Mr. Howell was elected.

Copies of a recent paper entitled "Statistical Control of Accidents," by John M. Howell, Quality Control Engineer and Lee Johnson, Safety Engineer of Northrup Aircraft Inc., were made available to members at the meeting.

THE SOCIETY OF QUALITY CONTROL ENGINEERS OF SYRACUSE

Monthly Meeting February 27, 1946, at Hotel Syracuse.

Mr. C. J. Kirtchen, research statistician at Remington Arms, Ilion, N. Y., gave to the Syracuse Society as a group its first insight into the workings of a Sequential Analysis of arms and ammunition, outlining the sequential principle involved and at the same time deriving and demonstrating applied mathematics. He summarized his talk with the presentation of a detailed monograph.

Scintilla Magneto Division and Easy Washing Machine Company, in the Syracuse area, have found sequential methods of evaluating vendor quality thoroughly satisfactory when used in their receiving departments.

Mr. R. W. Coolbaugh, president of the Syracuse Society, distributed to the membership forms and plans for "Quality Control in the Receiving Area," based on actual experience in the Easy Washing Machine Plant, Syracuse, N. Y.

Monthly Meeting March 26, 1946, at Hotel Syracuse.

Mr. Clifford W. Kennedy, Quality Manager of the Federal Products Corporation at Providence, R. I., described "Random Samples of Industrial Quality Control in Use." His talk brought forth vividly, without going into mathematical exposition, just what answers can be evolved by "Quality Control Thinking." His "Random Samples" included such diversified subjects as chocolate candy, razor blades, and automobiles. Many of his points struck home as he demonstrated his knowledge of the actual problems met "out in the shop."

During the business meeting the following officers were elected for the ensuing term: Mr. R. W. Coolbaugh, Easy Washing Machine Company, President; Mr. F. F. Graumenz, Carrier Corporation, Vice President; Mr. J. N. Emlich, General Motors Corporation, Secretary; Mr. J. R. Sadowski, Halcomb Steel Division, Crucible Steel Corporation, Treasurer.

MICHIGAN SOCIETY FOR QUALITY CONTROL

The Michigan Society held its second annual MANAGEMENT NIGHT at the Rackham Memorial Building in Detroit on Thursday evening 2nd May at 7:30 P. M. The speakers were Dr. W. D. Baten of Michigan State College, and Mr. G. D. Edwards, Director of Quality Assurance at Bell Telephone Laboratories, and President of the American Society for Quality Control. Dr. Baten spoke on "100% Inspection vs. Sampling Inspection vs. Quality Control," and Mr. Edwards on "The Future of Quality Control."

The meeting turned out to be the most largely attended of any so far held by the Michigan Society. About 150 people were present.

The Michigan Society has recently adopted substantial changes in its by-laws, to bring its name and fiscal year into correspondence with American Society practice.

SOCIETY OF QUALITY CONTROL ENGINEERS OF BUFFALO

At the April 25 meeting, 110 members and guests heard Joseph Manuele, Westinghouse Electric Corporation, speak on "Fundamentals and Savings of Quality Control." Mr. Manuele stressed the need for understanding of the purpose of quality control. The purpose is to standardize quality of product at a level acceptable to the consumer and in conformity to the concept of the product set forth by the design engineer in his blueprints. The function of a quality control department is to assist the production department in carrying out this purpose. By numerous illustrations, Mr. Manuele showed how quality control has assisted production in huge savings through correction of faulty operation, improper tooling, inefficient inspection procedures, etc.

MICHIGAN QUALITY CONTROL FORUM

Date: June 7, 1946.

Place: Book Cadillac Hotel, Detroit.

Time: 9:00 a.m.

To meet an expanding demand for knowledge of Quality Control Principles and Practices, the Michigan Society for Quality Control will conduct a one day Forum on June 7. Leaders in the field from all parts of the country will lecture and conduct discussion periods. A condensed program follows:

9:00 a.m. Registration.

10:00 a.m. Lectures.
Theory of Measurement Charts
Theory of Fraction Defective Charts
Theory of Sequential Analysis

12:15 p.m. Luncheon.

Speaker: Frederick J. Halton, Jr., Deere and Company.

Subject: Introducing Quality Control to Management.

2:15 p.m. Forums.
"Sequential Sampling"
"Methods for Short Runs and Job Shop Lots"
"Application of Fraction Defective Charts"
"Foundry Applications"
"Inspection Plans for Continuous Production"
"Training Personnel in Statistical Quality Control"
"Air Gaging in Quality Control"

4:00 p. m. Forums.
"Methods Applicable to High Production"
"Receiving Inspection"
"Tool Wear"
"Quality Control in the Chemical Industry"
"Sub Assembly Inspection"
"Quality Control in the Radio Industry"
"Keeping Up to Date in the Gaging Field"

6:30 p.m. Dinner.

Speaker: Joseph M. Juran, New York University.

Subject: Quality Control—A Management Tool.

A registration fee of $7.00 covers charges for attendance at Luncheon, Dinner and all Forum sessions. Further information can be obtained from Michigan Society for Quality Control, 731 Penobscot Building, Detroit 26, Michigan.

AN INTENSIVE COURSE IN QUALITY CONTROL FOR THE CHEMICAL INDUSTRIES AT ROCHESTER INSTITUTE OF TECHNOLOGY EVENING AND EXTENSION DIVISION

Emphasis will be on the applications of control technique in the chemical industries, including the basic principles of quality control, applications to analytical laboratory work and to production control.

Scope of Course

The concept of quality control; principles of frequency distribution analysis; the control chart approach and its use in both laboratory and production to detect assignable causes of variability and excessive variability; the design of experiments; principles of sampling and their application in both laboratory and production with emphasis on the problems peculiar to dealing with liquids, solids and gases; applications of significance tests, correlation, and analysis of variance; installation of a quality control system.

Date

June 20-June 27, 1946 (Except Sunday)

Morning and afternoon sessions

Instructors

Full-time: Martin A. Brumbaugh, University of Buffalo; Charles A. Bicking, Hercules Powder Company, Edward R. Close, Bausch and Lomb Optical Company. Part-time: Grant Wernimont, Eastman Kodak Company, Geoffrey Broughton, Eastman Kodak Company; Ronald H. Noel, Bristol Laboratories; (three or four others will be added).

Information

More detail can be obtained by addressing Burton E. Stratton, Director, Evening and Extension Division, Rochester Institute of Technology, Rochester 8, New York. The Institute will assist in making any hotel reservations required.

UNIVERSITY OF ILLINOIS COURSE

A ten day intensive course on Statistical Quality Control will be held June 4 to 14 at the University of Illinois. The course will include material on control chart techniques; single, double, and sequential sampling; applications to engineering design; introduction to correlation.

The instructional staff will include Professor Irving Burr, Purdue University, Professor John Henry, University of Illinois, Professor Edwin G. Olds, Carnegie Institute of Technology, and Professor Mason Wescott, Northwestern University.

The tuition for the course is $100 and the enrollment is limited to 50 students. Information can be obtained from Mr. H. C. Rountree, Assistant Director of Extension, University of Illinois, Urbana, Illinois.

SYLVANIA ELECTRIC PRODUCTS INC.

The type of Quality Control being established at Sylvania's Kew Gardens Laboratory is quite different from the normal acceptance control or process control. Here data are taken on all the component parts and processes in tube manufacture and by statistical means are analyzed in an attempt to correlate one group with another. More specifically a few of the many complex problems that exist are:

(1) To find the variations that may be tolerated in filament and heater wire, without causing the filament or heater Current to fall out of limits. Further, after a complete analysis has been made, and the filament current or heater current limits are known, to set statistically the inspection tolerance on the resistivity, weight or diameter of the wire itself.

(2) To determine the effect of dimensioned changes in cathodes, grids, plates etc. on the electrical characteristics of a tube; and then to work back and set statistically the tolerances on these parts knowing allowable variations in the electrical characteristics.

These examples serve to illustrate the great number of correlation problems at hand. Since the program is slightly different from the normal quality control, it has been termed "Engineering Analysis." This indicates the close connection between quality control and engineering and is one of the reasons why this type of work is referred to as Quality Control Engineering.

American Society News

Initial Board of Directors Completed

The seventeen Local Societies which participated in the organization meeting of the American Society for Quality Control have completed selection of their several representatives on the Board of Directors of the American Society.

In addition to the four American Society officers and the Chairman of its Editorial Board, as listed on page 4 of Industrial Quality Control, the initial Board of Directors of the American Society is comprised of the following seventeen Local Society representatives:

Boston: Charles J. Hudson
Buffalo: Alfred J. Winterhalter
Chicago: Ernest H. Robinson
Delaware: Arthur R. Kalmbacher
Georgia: Ralph A. Hefner
Illinois: Roman M. Hammes
Indiana: Harry B. Marsh
Iowa: Frederick J. Halton, Jr.
Michigan: Malcolm W. Blackwood
Milwaukee: Bernard F. Litzau
Newark: Paul S. Olmstead
Northwestern: Harry J. Becker
Ohio: Wade R. Weaver
Philadelphia: Harry W. Poole
Pittsburgh: Edward M. Schrock
Rochester: Halsey H. Kent
Syracuse: Richard W. Coolbaugh

Additional Local Societies Affiliated

Since the organization meeting, three additional Local Societies have affiliated with the American Society for Quality Control, viz: The California and Omaha Societies, and the newly-organized St. Louis Society.

The California and Omaha Societies have already designated their representatives on the Board, and the following are now fully accredited members of the Board of Directors of the American Society for Quality Control.

California: John M. Howell

Omaha: Carl W. Helmstadter

The St. Louis Society has not yet designated its member on the American Society Board.

Several further Local Societies have already taken initial steps toward affiliation with the American Society.

Executive Committee Completed

The members of the American Society Board of Directors representing the Local Societies in each of the six Regions into which the United States and Canada are divided for organization purposes, have now selected their several representatives on the Executive Committee.

In addition to the four American Society officers and the Chairman of its Editorial Board, the Executive Committee of the American Society for Quality Control is comprised of the following six Regional representatives:

New England Region: Charles J. Hudson
Middle-Atlantic Region: Paul S. Olmstead
Northern Region: Alfred J. Winterhalter
Central Region: Wade R. Weaver
Mid-West Region: Frederick J. Halton, Jr.
Western Region: John M. Howell

Committee Organization

In addition to the Advisory Council, the following Committees of the American Society for Quality Control are in course of formation:

Committee on Membership
Committee on Programs and Speakers
Committee on Relations with Technical Societies
Committee on Relations with Educational Institutions
Committee on Publicity and Public Relations
Committee on Professional Ethics, Professional Standards, and Grades of Membership
Committee on Constitution and By Laws

The plan for these Committees was set up at the February 16 Organization Meeting, and the allocation of personnel to the several Committees has been in process since that time. As soon as the membership is complete the entire set-up of operating Committees will be announced in INDUSTRIAL QUALITY CONTROL. The membership of the Advisory Council will also be announced in a future issue.

Michigan Society 100% American

The American Society has received from the Michigan Society for Quality Control a check covering American Society dues for all Michigan Society members for the period ending 30 June, 1947. This makes the Michigan Society the first of the Local Societies to have 100% of its membership identified with the American Society for Quality Control.

SPECIAL NOTE TO SUBSCRIBERS

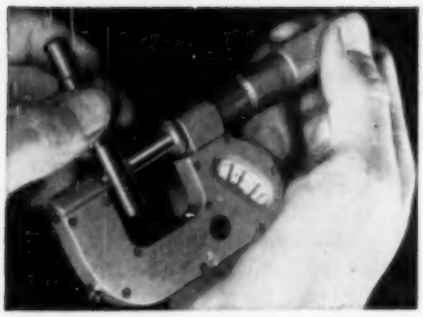
The March issue of the magazine contained a preliminary statement entitled, "Transition from Subscribers to Members." Therein was described the overall procedure by which it was hoped that all of the subscribers to INDUSTRIAL QUALITY CONTROL would become members of the American Society for Quality Control. Specifically the intention is to offer to each subscriber membership in the American Society when the current magazine subscription expires.

That plan is being implemented by a sequence of steps which will be followed after each issue of the magazine appears. A mimeographed list will be prepared in the Editorial Office containing the names and addresses of all persons whose subscriptions expire with the current issue and who are not members of the American Society. Copies of this list will be sent to local Secretaries of all Societies affiliated with the American Society. The Secretary of each Society will communicate with the subscribers in his territory whose names appear on the current list. Those subscribers residing in places remote from a local Society or outside the United States will be contacted directly by the Executive Secretary of the American Society.

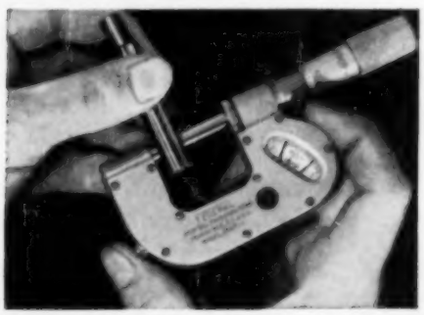
By this procedure it is hoped that every subscriber will be offered an opportunity to join the American Society. More than that, it is the Editor's belief that the improvement of the magazine through its espousal by the American Society fully warrants the expectation that all former subscribers will wish to become members of the American Society.

THE MICROMETER YOU HAVE BEEN WAITING FOR

THE FEDERAL INDICATING MICROMETER



USED AS A MICROMETER — spindle is brought into contact until Indicator reads "O".



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